This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

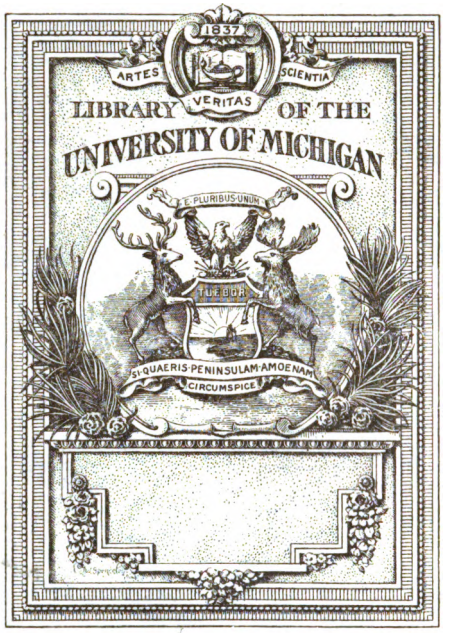
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



Digitized by Google

Astron.
Obs.
QB
1
.R883

Digitized by Google

Digitized by Google

MONTHLY NOTICES

OF THE

40882

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS,

ABSTRACTS OF PAPERS,

AND

REPORTS OF THE PROCEEDINGS

OF

THE SOCIETY,

FROM NOVEMBER 1856, *TO JULY* 1857.

VOL. XVII.

BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS OF THE ROYAL ASTRONOMICAL SOCIETY.

LONDON:

PRINTED BY

GEORGE BARCLAY, CASTLE STREET, LEICESTER SQUARE.

1857.

Digitized by Google

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *November* 14, 1856. No. 1.

MANUEL J. JOHNSON, Esq., President, in the Chair.

J. P. Radcliffe, Esq., Rudding Park, Yorkshire, was balloted for and duly elected a Fellow of the Society.

Occultation of Jupiter by the Moon. Observed at Canonbury November 8th, 1856. By Warren De la Rue, Esq., Ph.D. F.R.S.

Latitude 51° 32′ 40″·6 N.; longitude 23ˢ·24 W.

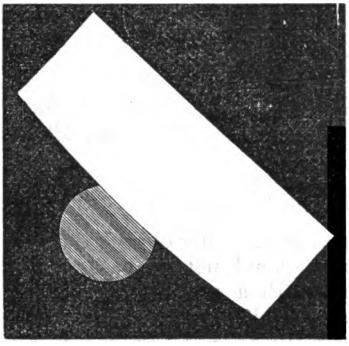
In consequence of the existence of intervening objects the first contact of the moon with the planet could not be observed in my observatory, but it was watched with a small achromatic of only one and a half inches aperture, with which, however, the time of contact might have been pretty accurately noted, had a chronometer been at hand, so excellent was the definition. But when the contact had fairly taken place, the planet had emerged from behind the surrounding objects and afforded me an opportunity of watching the progress of the moon's northern limb across the planet's disk with an excellent $2\frac{1}{2}$ object-glass of Ross, magnifying 120 diameters and mounted equatoreally by Simms. With this instrument the moon's limb was estimated to extend to within 3″ of the southern edge of the dark southern belt of *Jupiter*, which had been found by previous micrometrical measurements to be distant 13″·95 from his southern edge, so that the overlapping would be about 11″. I was much struck with the pale and evidently greenish hue which the planet presented in contrast with the moon's conspicuously warmer tints, and also with the much greater brightness of most portions of the lunar surface; for *Jupiter* was not even quite so bright as *Plato*, which by comparison appeared of a brown colour. I did not wait to observe the moment of emergence with the achromatic, as I hoped to be able to do so with my Newtonian equatoreal, but I could not get a sight of the planet until the moon was fairly separated by a streak of black sky; I was, however, able to confirm most satisfactorily the observations in regard to the relative tint and brilliancy of *Jupiter* as compared

Digitized by Google

with the moon, made with the smaller instrument. The shadow of the first satellite on the dark southern belt was distinctly seen and had been observed in the $2\frac{1}{2}$-inch telescope; and at $4^h\ 22^m\ 26^s{\cdot}9$ local sidereal time, the fourth satellite (the only one visible) reappeared from behind the moon at about 2″ from its limb; the disappearance of this satellite unfortunately could not be noted for the reason before mentioned.

Observation of the Occultation of Jupiter by the Moon, November 8, 1856. By W. Huggins, Esq.

"*Jupiter* appeared to run along the edge of the moon without contact for nearly a minute.



First Apparent Contact,
$4^h\ 30^m\ 3^s$ G.S.T.

Last Apparent Contact,
$4^h\ 36^m\ 38^s$ G.S.T.

"Edge of moon on *Jupiter* appeared to approach the upper equatoreal belt within about 4″.

"Dusky appearance of *Jupiter* as contrasted with the moon very marked.

"First satellite very visible.

"Fourth satellite not seen during the occultation.

"Telescope, 5 inches aperture; power, 160.

"*Upper Tulse Hill.*"

Observation of the Occultation of Jupiter, 8th November, 1856. By T. W. Burr, Esq.

"In consequence of the interest excited by the phenomena on this occasion, I am induced to add my notes of the occurrence to the accounts already before the Society.

"It was difficult to determine when the occultation really commenced, as the planet appeared to graze along the moon's limb for some little time at a part which was still rugged; but I believe the immersion may be stated to have occurred at $4^h\ 28^m\ 54^s$ local sidereal time. A slight cloud then formed, but was speedily dissipated, and at $4^h\ 30^m\ 18^s$ a distinct impression had been made on the planet's disk, which was then immediately under *Plato*, where the moon's limb was fully illuminated. The emersion I consider took place at $4^h\ 35^m\ 16^s$, when a fine, but palpable, dark line became visible between the disks. This line was not visible before, but the line of demarcation between the two bodies and

Digitized by Google

the extent of the obscuration of *Jupiter* could be seen by the difference of their light; the planet being dusky, compared with the moon. I made the same observation on the night of the recent eclipse of the moon, when, on occasionally turning to the planet, its light, though strong, was evidently less brilliant in its character than that of our moon.

"About one-fourth of the planet's disk seemed occulted; the whole of the mass of polar shading being covered, but a bright band remained above the upper equatoreal belt. The first satellite had come off the planet's disk about nine minutes before the occultation commenced, and was steadily visible during the whole time. Its shadow remained on the planet, and was likewise seen, as were the two principal belts and the fine ones, near the lower pole: The fourth satellite was visible before the occultation, but disappeared while I was watching the planet, and could not be found afterwards. I believe it suffered an occultation by our moon.

"*Highbury, 17th November*, 1856."

Note on the Occultation of Jupiter, November 8, 1856.
By W. R. Grove, Esq. F.R.S.

"I had a good position for witnessing the partial occultation of *Jupiter* from an upper room of my house, situate opposite Clarence Gate, Regent's Park. I used a small, but unexceptionably good achromatic telescope, $1\frac{3}{4}$-inch aperture and 22 inches focus; the magnifying power was 43.

"It seemed to me—(but I attach little value to the observation, as the effect might have been due to an agitation in the Earth's atmosphere)—that at the moment before immersion the margin of *Jupiter* was slightly elongated, or, so to speak, stretched itself out to meet the Moon; this was followed immediately by a flattening of the same portion of the disk.

"Throughout the whole period a dark line was plainly perceptible between *Jupiter* and the Moon. This line appeared to me straight, as though cutting off the convexity both of *Jupiter* and the Moon. The light of *Jupiter* was notably less brilliant than that of the Moon; I should say hardly equal to half the intensity of the latter. It was of a much bluer tint than the Moon, probably an effect of contrast arising from the different intensities of their respective lights. The belts of *Jupiter* were plainly seen throughout the occultation, and, as far as I could observe, were not in any respect distorted.

"The dark line I thought at first arose from the intervention of a fine rim of the dark body of the Moon, but this could hardly be the case towards the termination of the occultation. About a fifth part of the planet appeared to me to be occulted at the maximum period."

Digitized by Google

Note on the Occultation of Jupiter. By J. F. Goddard, Esq.

"I take the liberty of sending you an account of my observation of this phenomenon. I used an achromatic telescope of $4\frac{1}{8}$-inch aperture, and power of 200. Circumstances were very favourable; not a cloud passed, there was little or no wind, and the smoke of London did not drift in our direction.

"The planet approached the north point of the moon's limb nearly in the direction of a tangent to that point, passing the invisible limb at a small distance, and making its first contact with the moon at the limit of light and darkness; it remained on the edge a little while, and one-fourth of its disk was gradually obscured, a darkish line being sensible between. The planet glided along the bright circular outline of the moon; its hue was duller than that of the moon. I could not affirm that any alteration of size or figure occurred, but I took no measurements. The centre of *Jupiter* was not occulted, only, as near as I could guess, one-fourth of his diameter. The belts and one satellite were conspicuous all the time.

"The observation was made about half-a-mile south of Hounslow Railway Station.

"*Jesse Cottage, Whitton, near Isleworth, November 13th*, 1856."

Note respecting the Occultation of Jupiter by the Moon. By Lord Wrottesley.

"We looked out for the occultation of *Jupiter*, but none took place here. The moon passed about four diameters of *Jupiter* to the south of the planet. We observed, however, an eclipse of the third satellite of *Jupiter* by the planet.

"Disappearance at $11^h\ 9^m\ 45^s$, M. T. at Wrottesley.

"Reappearance at $13^h\ 52^m\ 41^s$ M. T. ,,

"The former gives a very fair longitude.

"*Wrottesley, Nov.* 10, 1856."

Observation of a Lunar Occultation of Jupiter's fourth Satellite, made at Haddenham, Bucks, November 8, 1856. By the Rev. W. R. Dawes.

"The conjunction of the moon with *Jupiter* on the 8th of this month presented, as seen from this place, the rare phenomenon of an occultation of a satellite, while the planet itself escaped being even partially occulted. At the nearest approach, the southern limb of *Jupiter* was still about 20″ or 25″ by estimation from the

Digitized by Google

northern edge of the moon. The fourth satellite was the only one visible until within a few minutes before the time of conjunction, when the egress of the first took place (at about $13^h\ 5^m$ G. M. T.). Being in the south-following portion of its apparent orbit, it was caught by the moon in consequence of her rapid advance in declination northward, disappearing at the dark edge of the moon, and reappearing at the bright edge. My large equatoreal not having been remounted since my removal from Wateringbury, I employed a very perfect refractor by Merz of Munich, having an aperture of only $2\frac{1}{2}$ inches. With this the fourth satellite, though at times faint, and seen with difficulty when the air was much disturbed, yet was traced satisfactorily up to the moon's dark edge; but at the reappearance of the bright edge, it was not seen with certainty till it was distant from the limb about two of its own diameters. The duration of its occultation is therefore uncertain. The shadow of the first satellite was very obvious on the large belt in the southern hemisphere of the planet.

"P.S. The approximate geographical position of my present temporary residence is: longitude, $3^m\ 40^s$ west; latitude, 51° 46′ north.

"*Haddenham, Bucks, 10th November*, 1856."

In answer to some inquiries on the part of Mr. De La Rue, Mr. Dawes makes the following observations:—

"I am obliged by your note of the 12th, to which I have been, till now, unable to reply. I was struck, as you were, with the difference of tint of *Jupiter* and the moon. Though the approach was so much closer as seen from here than at Nottingham, I did not perceive the slightest distortion of *Jupiter's* form similar to that described by Mr. Lowe in his letter to the *Times*.

"*Haddenham, Bucks*, 20 *Nov.* 1856."

Observations of Jupiter, during October 1856. By Warren De la Rue, Esq., Ph.D., F.R.S.

"*Jupiter* has been during the present apparition a most remarkable and interesting object, both on account of the great amount of detail to be seen on his belts, and also of the changes which obviously occur in them during very short intervals. The general appearance of the belts recalls very vividly the mottled and streaked appearance frequently presented by clouds, but no description can convey an accurate notion of the markings on the planet without the aid of graphic representations. There is, however, very great difficulty in making drawings of *Jupiter*, in consequence, partly of the overwhelming amount of details to be seen, and partly on account of the short period allowed by the rapid axial rotation of the planet for their delineation. For unless the drawing be completed within twenty to thirty minutes at most,

Digitized by Google

the change of aspect will have become so great, in consequence of the foreshortening and disappearance of some parts, and the fresh appearance and the elongation of others, that no reliable result will be obtained. And it frequently happens, moreover, that observations begun most auspiciously are rendered useless by the definition suddenly becoming bad and continuing so during the short interval at command; and by the time the atmosphere has quieted, the planet may have rotated so much that it is necessary to recommence, to be disappointed possibly again and again. Notwithstanding many such disappointments I am enabled to lay before the Society four faithful drawings, three of them executed by myself, and the fourth by my chemical assistant and friend Dr. Müller, who is a rapid and accurate draughtsman, and whose faithfulness in planetary delineation I have had many opportunities of testing.

"The southern belt of *Jupiter* appeared, on most occasions on which I have observed it, to be somewhat darker than the northern, which has always been more diffuse and more broken up by intervals and streaks; the northern also has invariably been the broader of the two. Both belts are unmistakably brown as compared with the general tint of the planet, which, about the poles, has a decidedly yellow hue, and more obviously so towards the north. Besides the very conspicuous broad belts, there were observed several delicate and faint streaks extending to a greater or less distance across the disk, but seldom entirely across it; these faint streaks just under the north belt were decidedly yellow. On the eastern limb of the planet (the most distant from the sun), I have observed a decided amount of shading, an observation confirmed by Dr. Müller.

"The belts of *Jupiter* have been usually represented to be bounded by straight lines: in former years I have always had the impression of an appreciable amount of curvature in them, and this observation I have been enabled to confirm during the present apparition. The belts are now so irregular in outline that it is quite necessary to watch for a favourable opportunity in order to test this impression satisfactorily; and it is absolutely essential that there should be no atmospheric tremor; fortunately such a rare occasion was presented on the 30th October at $7^h\ 50^m$ G.M.T. when the northern belt was sufficiently regular in its southern outline to admit of its elliptical form being made evident by laying a spider line tangentially upon it; the curvature, though very apparent, is small, and has its convexity towards the southern limb.

"The drawings represent the planet at the following epochs: October 12th, 12th hour G.M.T.; October 25th $9^h\ 8^m$ with the first satellite and its shadow upon the disk; and two drawings on October 27th, the one at $8^h\ 50^m$, the other by Dr. Müller at $9^h\ 45^m$, when the planet had rotated 33° 15′. The drawings of October 12th, and the first drawing of October 27th, represent the same hemisphere (the difference being only 15° 29′) and show very clearly the changes which during the interval had taken place in the belts which still retained some of their general features.

Digitized by Google

"The drawing of the 12th October was made in an ellipse set out previously from the data given in the *Nautical Almanac* to the scale adopted in all my previous drawings, namely, 0·125 inch to the second of arc; the dimensions and positions of the belts being eye observations. The figure was, however, so obviously too flattened an ellipse, that I was induced to measure the planet, and obtained a complete confirmation of my suspicion; on all other occasions I have made measurements not only of the planet, but also of his belts before commencing a drawing. I subjoin the results in so far as they relate to the polar and equatoreal dimensions of the planet, reserving the full details for another communication. I have reduced the observations also to the mean distance 5·20279, adopted by Mr. Main in his valuable paper 'On the Diameters of Planets having Measurable Disks.' The inclination of the belts was found to be:—

Oct. 12 ..... 23° 25′
,, 30 ..... 26 34

Date of Observation.	Observed		Reduced		Deduced Ellipticity neglecting the Slight Correction for Phase.*
	Equatoreal Diameter.	Polar Diameter.	Equatoreal Diameter.	Polar Diameter.	
1856.	Means of Eight Measures.	Means of Eight Measures.			
	″	″	″	″	
Oct. 25	47·500	44·800	37·247	35·131	0·05681
27	47·080	44·720	37·075	35·217	0·05011
30	46·793	44·267	37·100	35·090	0·05418
			37·141	35·146	0·05370 = $\frac{1}{18·62}$

Telescopic Appearances of the Planet Saturn during the Apparition of 1855–6, as observed with an 8-inch Object-glass. By the Rev. W. R. Dawes.

This communication will be published *in extenso* in another form. In commencing, Mr. Dawes states that "the object-glass, with which the following observations were made, is the work of Mr. Alvan Clark, of Boston, U.S., the same excellent maker who furnished me with the 7½-inch glass, with which I observed the previous year. Its focal length is 10 feet;—rather too great for convenience in my dome, which was constructed for an 8½-foot telescope: and the artist is therefore only waiting for unexceptionable materials wherewith to construct an object-glass of

* Mr. Main remarks that, if the *Correction for Phase* were allowed for, the resulting ellipticity would be nearly identical with his own determination.

Digitized by Google

the same aperture, with a considerable diminution of focal length The present 8-inch is a remarkably clear and sharp definer; and has afforded me some of the finest views of *Saturn* which I have ever enjoyed. Under suitable circumstances, it shows a minute but clear separation between the components of γ^2 *Andromedæ*."

The observations that follow are extracts from the entries in his observatory journal made at the time of observation.

Outer Ring, distinguished by Mr. Dawes as A. The pencil line on the outer ring was observed on Dec. 15 and Dec. 18, 1855, and on Feb. 15, 1856.

Middle Ring B. The dark band near the inner edge of the middle ring was seen distinctly defined on many occasions; and Mr. Dawes thinks that the bright line close to its inner edge is broader and less bright than on former occasions. Mr. Dawes notices an appearance of indistinctness on a part of the inner edge of the middle ring, which seems to confirm the opinion already placed on record by Mr. De la Rue, respecting the overlapping of the dusky ring on the middle ring.

"The inner edge of B is remarkably less distinct on the eastern side than on the western. I cannot account for this.

"1855, Dec. 19. Mr. F. Barrow visited the Observatory, and saw *Saturn*. . . . Without any intimation from me, he noticed the less defined appearance of the inner edge of the ring B on the south-following (or south-eastern) side; and suggested that it might be owing to the plane of the obscure ring C being inclined to that of the bright rings. This strikingly confirms my observation of last night.

"1855, Dec. 20. The same difference in the distinctness of definition of the inner edge of B on the eastern side and on the western is noticed, as I have before recorded."

Obscure Ring C. Mr. Dawes notices differences in the tint of different portions of the dusky ring, and that its light fades off towards its inner edge. He also, on one occasion, Nov. 15, 1855, made out a black line between it and the inner edge of the middle ring; but on the preceding side only.

The Ball. Mr. Dawes has paid particular attention to the markings on the disk of the planet, and also on the extent to which its southern limb covered the principal division between the outer and middle rings; the following observations relating to the period of the greatest opening of the rings are of interest.

"1855, Dec. 15. I cannot be sure that any part of the division is visible at the southern point of the ball, which I believe entirely covers it.

"1856, Jan. 29. I think the whole breadth of the division between A and B is not entirely covered by the ball, though I believe the greater part of it is so. . . . No very distinct belts on the ball. The polar belt appears to be less dark than it was during the earlier part of this apparition; and so is the narrow belt at about 40° south latitude.

"1856, Feb. 15. The southern edge of the ball does not

Digitized by Google

cover more than from one-half to two-thirds of the division between A and B.

"1856, Feb. 16. The southern edge covers, I think, rather more than half the breadth of the division . . . . The narrow belt, at about 45° or 50° of south latitude, is at times well brought out.

"1856, March 24. The ball appears to me to cover a small portion of the breadth of the division; but the air is scarcely favourable enough to determine it.

"1856, March 28. I cannot feel certain of the continuation of the division beyond the southern edge of the ball.

"1856, April 4. Very careful scrutiny leaves no doubt on my mind that the division between A and B is partly covered by the southern edge of the ball. When vision is finest, an extremely narrow dark line, like a hair, is seen to extend across the top or southern point of the ball; beyond which it is soon lost in the shadow of the ball."

Shadow of the Ball. The observations of the shadow of the ball on the rings extend from Nov. 15th, 1855, to April 4th, 1856.

On March 24, 1856, he remarks:—"The shadow of the ball certainly falls on A. The exterior edge of the shadow on B has a pretty regular though slight convexity, and is not *recurved* at the exterior edge of B, where the shadow of the ball joins the division between A and B."

The paper also contains several observations of *Enceladus*.

In conclusion he remarks:—"In No. 1017 of the *Astron. Nachr.*, Professor Secchi has given a brief account of the admirable performance of the large refractor by Merz, at the Observatory of the Collegio Romano; in which is the following remark respecting the position of the southern edge of the ball of *Saturn* on 1855, Dec. 16. 'The vertex of the globe scarcely touched the edge of the ring A.'

"It seems, therefore, that at that time Professor Secchi's impression almost perfectly coincided with my own.

"I ought, perhaps, here to offer a word or two in explanation of an expression which I employed when referring to this point in my paper printed in the *Monthly Notices* for 1855, Jan. 12, and in No. 971 of the *Astron. Nachr.* When I there spoke of 'a change to a considerable, and, in fact, *unaccountable*, amount having taken place,' if certain observations were correct, I intended simply to say, that there was *no well-known or recognised cause*, which was sufficient to account for it:—the variation which had occurred in the obliquity of the plane of the ring being obviously insufficient. Several causes, *more or less probable*, might be assigned for it, as Professor Secchi has shown in his remarks on my expression; but to such I was not referring when I used it.

"*Haddenham, near Thame,*
October, 1856."

Digitized by Google

Note on the Division of the Outward Ring of Saturn. By John Hartnup, Esq., Astronomer to the Liverpool Observatory.

"I have on several occasions been requested, both by Mr. Dawes and by Mr. Lassell, to try if I could make out the division in the exterior ring of *Saturn* with the equatoreal of this Observatory.

"On the 8th of November instant, after watching the near approach of *Jupiter* to the moon, with my friend Mr. Towson, I turned the telescope on *Saturn*. The definition was scarcely better than of average goodness, 27° being the highest power that the planet could be seen with to advantage. The semi-transparent ring was seen tolerably well, and the division in the exterior ring presented itself to my view in a few seconds. To put the matter beyond a doubt, I requested Mr. Towson to look at the exterior ring, and describe to me what he saw. After a careful examination, he drew on paper a sketch of the ring, which agreed precisely with my impression, placing the division about one-third the width of the ring from the exterior edge. I then showed Mr. Towson the beautiful engraving of Mr. De la Rue for 1852, and he immediately said that the division was too near the centre of the ring; but on his seeing Mr. De la Rue's engraving for 1856, he remarked that the division was correct. It is worthy of notice, that I have frequently seen *Saturn* better defined than on this occasion, with powers of 400 and 600, without being able to detect the division in the exterior ring.

"*Observatory, Liverpool,*
Nov. 13, 1856."

Note accompanying Drawings of Mars. By Capt. W. S. Jacob, Astronomer to the H. E. I. C.'s Observatory, Madras.

The accompanying drawings of *Mars* were taken at the last opposition. They are arranged and numbered, *not* in the order in which they were observed, but in that of the revolution of *Mars*, so as to give a better notion of the succession of phases. The date at which each was taken is given below. The colours have been represented as nearly as possible: the greenish hue, which some observers have remarked in the dark spots, was not noticed; the hue appeared similar to the usual appearance of the earth's shadow on the moon, which also is frequently considered to be green, but which (when not of a coppery tinge) always appears to the writer as a neutral brown or dun. Most of the marks appear to be quite permanent. Those near the south or upper Pole of No. 4, gave the impression of a chain of lakes somewhat similar to those of North America, but larger.

The instrument used was the Lerebours' equatoreal $f = 88^{in.}\cdot 6$ $ap = 6^{in.}\cdot 25$, power 277.

Digitized by Google

Dates of Observation.

No.	Madras Mean Time. d	h	m
1	April 11	7	0
2	May 15	6	45
3	,, 12	6	50
4	,, 7	6	15
5	,, 9	10	55
6	April 21	7	20
7	,, 16	6	50

There is rather a wide gap between No. 5 and 6, the interval being about 90° of longitude; the rest follow pretty regularly at intervals of 40° to 50° round the whole circumference. The drawings are made to a scale of $0^{in.}{\cdot}15$ to $1''$.

Madras, 11 *Sept.* 1856.

The beautiful drawings alluded to in this communication, together with those of Mr. De la Rue, Mr. Brodie, and those made at the Royal Observatory at Greenwich, have been referred to a Committee of the Council, with a view of mapping out the surface of *Mars*.

Note on the Observations of Antares. By J. Hippisley, Esq.

"In reference to the observations at p. 222, vol. xvi. of the *Royal Astronomical Society's Notices*, as to the impossibility of seeing *Antares* as a double star in these latitudes, I send the following extract from my observatory memoranda:

"1856, July 20, $8^h\ 30^m$, *Antares* in the meridian, · ● the small star very well seen, with powers 150 and 234.
"$8^h\ 45^m$, δ *Cygni*, saw the small star instantly with 234.
"July 30, $8^h\ 3^m$, *Antares* seen instantly and beautifully, · ● power 234, the small star about 1·5 diameter from the larger.

"I regret that I did not use a micrometer, but merely set down the position and distance by estimation; as in the diagram, which is a facsimile traced from my note-book, and represents the small star almost exactly 'preceding.'

"I am induced to send this extract as an instance, out of many I have experienced, of the great value of the half-hour at and after sunset, for the more delicate and difficult observations in all cases where the object has light enough to be well visible telescopically by daylight, such as exists at that period. This may probably arise from the short equilibrium between the heat of day and the chill of evening; during which atmospheric disturbances, arising from the intermixture of beds of air of different temperatures and densities, may be expected to be at a minimum.

"The observations were made with a $9\frac{1}{4}$-inch Newtonian equatoreal, and *without* any previous knowledge of the angle of position of the smaller star.

"*Ston Easton, Bath,*
Oct. 26, 1856."

Digitized by Google

Magnitudes of Thirty-six of the Minor Planets for the First Day of each Month of the Year 1857. By Norman Pogson, Esq., Assistant at the Radcliffe Observatory, Oxford.

(*Communicated by M. J. Johnson, Esq., Radcliffe Observer.*)

No.	Planet.	M.	Jan.	Feb.	Mar.	Aprl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1858. Jan.
1	Ceres.....	7·5	7·4	7·1	7·1	7·4	7·8	8·1	8·4	8·6	8·8	8·9	9·0	8·9	8·8
2	Pallas.....	7·9	6·8	6·7	6·8	7·1	7·6	8·0	8·4	8·7	9·0	9·1	9·2	9·2	9·1
3	Juno	8·7	9·4	9·4	9·5	9·4	9·4	9·3	9·2	9·1	9·0	8·8	8·6	8·3	8·1
4	Vesta.....	6·4	7·0	7·3	7·6	8·0	8·2	8·4	8·5	8·5	8·4	8·3	8·1	7·8	7·5
5	Astræa	9·9	12·2	12·3	12·3	12·2	12·0	11·8	11·4	11·0	10·6	10·3	10·2	10·4	10·6
6	Hebe	8·5	9·2	9·1	9·2	9·6	10·0	10·4	10·7	10·9	11·0	11·1	11·0	10·9	10·7
7	Isis.....	8·5	10·5	10·2	9·9	9·7	9·7	9·9	10·3	10·6	10·8	11·0	11·1	11·1	11·0
8	Flora	8·7	10·4	10·4	10·4	10·3	10·2	10·1	9·9	9·7	9·5	9·3	8·9	8·6	8·4
9	Metis.....	8·7	10·5	10·6	10·5	10·5	10·3	10·1	9·9	9·5	9·1	8·7	8·2	7·9	8·0
10	Hygeia	9·8	11·1	11·3	11·4	11·4	11·4	11·3	11·1	10·9	10·6	10·3	10·3	10·4	10·7
11	Parthenope .	9·6	10·6	10·2	10·1	10·3	10·6	11·0	11·2	11·4	11·5	11·6	11·5	11·4	11·3
12	Victoria....	9·8	11·2	10·9	10·5	10·1	9·6	9·1	8·7	8·4	8·4	8·9	9·5	10·1	10·6
13	Egeria	9·7	11·4	11·2	11·0	10·7	10·3	10·1	10·2	10·4	10·8	11·1	11·4	11·6	11·7
14	Irene	9·8	11·8	12·0	12·1	12·1	12·1	11·9	11·7	11·4	11·1	10·7	10·4	10·3	10·5
15	Eunomia...	8·5	8·2	8·7	9·0	9·3	9·6	9·8	9·9	10·0	10·0	9·9	9·8	9·6	9·3
16	Psyche.....	10·0	10·7	10·5	10·5	10·7	11·1	11·4	11·7	11·9	12·0	12·0	12·0	11·9	11·7
17	Thetis	9·9	11·3	11·3	11·3	11·2	11·0	10·8	10·5	10·2	10·0	10·0	10·3	10·7	11·2
18	Melpomene.	9·4	9·0	9·6	10·1	10·6	10·9	11·2	11·5	11·6	11·7	11·7	11·6	11·4	11·1
19	Fortuna	9·5	9·6	10·0	10·3	10·6	10·8	11·0	11·1	11·2	11·2	11·1	11·0	10·7	10·4
20	Massilia....	9·2	9·1	9·5	9·8	10·1	10·3	10·4	10·6	10·7	10·7	10·7	10·6	10·5	10·3
21	Lutetia	10·5	10·9	11·4	11·8	12·2	12·5	12·7	12·8	12·9	12·9	12·8	12·6	12·3	12·0
22	Calliope....	10·2	11·1	11·3	11·4	11·4	11·4	11·3	11·1	10·9	10·6	10·3	9·9	9·7	9·7
23	Thalia	10·7	11·0	11·3	11·4	11·5	11·6	11·6	11·5	11·5	11·4	11·3	11·1	10·9	10·7
24	Themis	11·6	12·3	12·6	12·8	12·9	12·9	12·9	12·8	12·6	12·4	12·1	11·7	11·3	11·1
25	Phocea.....	10·7	12·0	11·6	11·1	10·6	10·0	9·5	9·2	9·2	9·5	9·9	10·4	10·9	11·3
26	Proserpine..	10·8	11·3	10·9	10·6	10·6	10·9	11·2	11·5	11·8	12·0	12·1	12·2	12·2	12·1
27	Euterpe....	10·2	11·7	11·8	11·8	11·8	11·7	11·6	11·4	11·2	11·0	10·8	10·4	10·1	9·7
28	Bellona	10·3	11·7	11·9	11·9	12·0	11·9	11·7	11·5	11·3	10·9	10·5	10·1	9·7	9·6
29	Amphitrite .	9·1	9·0	9·4	9·8	10·1	10·4	10·6	10·7	10·8	10·8	10·8	10·6	10·4	10·1
30	Urania.....	10·1	12·1	11·8	11·5	11·1	10·8	10·7	11·0	11·3	11·6	11·8	12·0	12·1	12·1
31	Euphrosyne.	11·3	12·6	12·4	12·1	11·9	11·8	12·0	12·3	12·6	12·9	13·2	13·3	13·4	13·4
32	Pomona	11·0	12·4	12·2	12·0	11·7	11·4	11·1	10·9	11·1	11·5	11·9	12·3	12·6	12·8
33	Polyhymnia.	11·2	13·2	12·9	12·7	12·7	12·8	13·1	13·3	13·4	13·5	13·5	13·4	13·3	13·0
34	Circe	11·6	13·5	13·6	13·7	13·6	13·5	13·3	13·0	12·7	12·3	12·0	11·8	12·0	12·3
35	Atalanta....	12·5	13·1	12·9	12·9	13·1	13·6	14·0	14·4	14·6	14·8	15·0	15·0	14·9	14·8
36	Fides	10·8	11·0	10·7	10·7	11·0	11·4	11·9	12·3	12·6	12·8	12·9	13·0	13·0	12·9

The column headed M in the preceding table gives the mean opposition-magnitudes for the thirty-six minor planets, ephemerides of which have been published in the supplement to the *Nautical Almanac* for 1860, *i. e.* the magnitudes such planets would have, if when in opposition both they and the Earth were at mean distance from the sun. These numbers have, for the most part, been deduced from estimated magnitudes near opposition, reduced to mean distance; and when such could not be obtained from my own or other observations, the values given by Prof. Argelander and

Digitized by Google

Dr. Bruhns, in their papers on the subject, have been adopted. (*Astronomische Nachrichten*, Nos. 928 and 1047.) The other columns furnish the magnitudes of the planets for the first day of each month, calculated on the assumed ratio of the light of 2·512, *i. e.* that a star of any magnitude, as for instance the eighth, contains 2·512 times the light of the next less, or ninth magnitude. A comparison of the brightest predicted magnitude of any planet with the number in column M, will show whether such planet is favourably situated for observation in the year 1857 or not. Thus, for *Polyhymnia*, which comes in opposition about the middle of March, when a little past its aphelion passage, the brightest magnitude will be 12·7, or 1·5 magnitude fainter than if at mean distance; while for *Phocea*, which will be very favourably situated at its opposition in July, the sun being in apogee and *Phocea* in perihelion, the magnitude will be 1·5 brighter than at mean distance. It must, however, be remembered, that an error in the assumed value of M for any planet will cause a corresponding error in the ephemeris throughout the year, and at present these quantities are by no means satisfactorily determined, especially for the more recently discovered planets. But, perhaps, the greatest use of such an ephemeris will be on the occasion of the earliest observations after conjunction, when an approximate knowledge of the magnitude may save the annoyance of mistaking an adjacent star for the object sought, an accident of too common occurrence even to experienced observers. Six planets have been omitted for want of ephemerides: for one of these, *Daphne*, no elements have yet been computed. For the remaining five, the numbers M may be taken as follows:—*Leucothœa*, 12·5; *Leda*, 11·5; *Lætitia*, 8·8; *Harmonia*, 8·5; and *Isis*, 10·3. Their magnitudes at any time may then be found by the formula,—

$$m = \mathrm{M} - 5 \log (a \,.\, \overline{a - 1}) + 5 (\log r + \log \Delta).$$

The magnitude-ephemeris will also be a severe test of the truth of the adopted light ratio; for if that ratio be really the one employed by the majority of observers, the correction for any one planet will be the constant one due to the number in the column M; but if, on the contrary, the ratio should be false, the ephemeris will run wide of truth, especially as each planet approaches conjunction, but this I do not anticipate.

The considerations which led to the adoption of the light ratio here employed were as follows:—I had read with much interest the remarks made by the Rev. W. R. Dawes, in the *Monthly Notices*, vol. xi. pages 187–198, and intended to make use of his proposed ratio of 4, when the very different result of 2·43, obtained by Mr. Johnson from his heliometric equalisation experiments, as given in his appendix to vol. xii. of the *Radcliffe Observations*, on the 'Photometry of Stars,' threw uncertainty upon a matter I had regarded as settled. The subject being one of especial importance in the pursuits which had occupied most of my leisure hours, viz., chart-making and variable star-observing, I at once set to work with a little modification of the method of reduced apertures,

Digitized by Google

to see which result my own observations would yield the nearest approximation to. I must even confess to having entertained at starting a little bias in favour of the ratio given by Mr. Dawes. Instead of reducing stars to a *minimum visible*, their total extinction was preferred, as being more certain. Having found by trial the apertures with which certain stars of assumed magnitude were lost sight of, these measures were grouped together, and submitted to the formula,—

$$(M - m) \log R = 2 (\log A - \log a).$$

in which R is the required ratio; M, *m*, the magnitudes of stars as widely different as possible, and A, *a*, the respective apertures with which each star vanished. The assumed magnitudes were taken from the *Radcliffe Observations*, from the zones of Argelander and Bessel, and from the catalogues of Piazzi, Lalande, and Groombridge, so as to find the ratio of each observer separately. The ratios thus found were remarkably accordant: the mean of all, 2·4. This result, derived by a perfectly independent method, was an unexpected verification of Mr. Johnson's ratio of 2·43. (The decreasing ratio of 0·412 was given by Mr. Johnson, but I prefer using its reciprocal.) Shortly afterwards I learnt that Steinheil, of Munich, had deduced a ratio of 2·83, by experiments upon 26 stars between the 1st and 4th magnitudes. Prof. Stampfer found, from 132 stars between the 4th and 9·5 magnitudes, a ratio of 2·519. Finally, Argelander has endorsed this ratio with his high authority upon such matters, by adopting it as the basis of his formulæ for computing the magnitudes of the minor planets. It signifies little which of these ratios is adopted in dealing with the ranges of ordinary telescopes. I selected 2·512 for convenience of calculation, as the reciprocal of $\frac{1}{2}$ log R, a constant continually occurring in photometric formulæ, is in this case exactly 5. If then any observer will determine for himself the smallest of Argelander's magnitudes just discernible by fits, on a fine moonless night, with an aperture of one inch, and call this quantity L, or the limit of vision for one inch, the limit *l*, for any other aperture, will be given for the simple formula,—$l = L + 5 \times \log$ aperture.

Numerous comparisons, made with various telescopes and powers, at different seasons of the year, have furnished me with the value L = 9·2 for my own sight, which is, I believe, a very average one, and therefore suitable for such a determination. As a verification of these results, Mr. Hind, who has extended Bessel's scale downwards in the construction of Mr. Bishop's Ecliptical Charts, has considered that with the South Villa equatoreal of 7 inches aperture, "a faint glimmering," to use his own words, was about a 13 or 13·14 magnitude. By the formula, we have for 7 inches, $l = 9{\cdot}2 + 5 \log 7 = 13{\cdot}4$ magnitude. Again, a 6th magnitude of Argelander is, *by trial*, my limit for an aperture of 0·23 inch. The formula gives for such an aperture, $l = 9{\cdot}2 + 5 \log 0{\cdot}23 = 6{\cdot}0$ magnitude.

It appears, then, that whatever they may have intended, nearly all the great catalogue-makers have involuntarily fallen into this ratio, or one so nearly the same as to be practically identical.

Digitized by Google

True, they have not all adopted precisely the same standard of brightness for any one magnitude, but if we take Argelander's 8th or 9th magnitudes and this ratio, all will be sufficiently close to fall considerably within the errors of estimation. Lalande's 6ths and 7ths are perhaps the most out; the rest present on the whole very fair agreement.

It remains to treat of those who have adopted a different ratio. Struve has divided the stars between the limits of naked-eye vision and of his 15-inch refractor into 6 magnitudes, *i. e.* he has made 12th magnitude the limit of vision for his instrument. The formula gives 15·1 magnitude for its limit. Mr. Dawes has adopted Struve's magnitudes, and therefore the same table will apply to both. Mr. Bond, with a similar telescope, has gone to the 20th magnitude, starting from Bessel's 9th magnitude. But according to the proportional apertures given for stars from the 9th to the 12th magnitudes on page liv. of the Introduction to the *Harvard Zone Observations*, he has not followed any fixed ratio in these four magnitudes, so all that can done is to tabulate for these, and simply interpolate between his 12ths and 20ths. For Sir John Herschel's estimates I must assume, as in Mr. Dawes' table, agreement with other authorities at the 6th magnitude, but that his 18th equals Struve's 12th (my 15·1 magnitude). Admiral Smyth in his *Cycle* took 16th magnitude as the limit for his aperture of 5·9 inches. The formula gives 13th magnitude, and supposing that his 8th magnitude was the point of departure from Piazzi, whose brighter magnitudes he professedly conformed to, we may interpolate the intermediate magnitudes.

The following table exhibits these equivalents in a collected form. The first, or standard column, contains Argelander's scale, extended to the lower magnitudes by the adopted ratio; the second, the apertures required by an average sight to reduce such stars to a limit of vision, and the remaining columns, the corresponding magnitudes of Struve, Bond, Herschel, and Smyth:—

Standard Magnitudes.	Apertures in Inches.	Corresponding Magnitudes of Struve.	Bond.	Herschel.	Smyth.
6	0·229	6·0	6·0	6·0	6·0
7	0·363	6·6	7·0	7·3	7·0
8	0·575	7·3	8·0	8·6	8·0
9	0·912	8·0	9·0	10·0	9·6
10	1·44	8·6	10·0	11·3	11·2
11	2·29	9·3	11·6	12·6	12·8
12	3·63	10·0	12·9	13·9	14·4
13	5·75	10·6	15·2	15·2	16·0
14	9·12	11·3	17·5	16·6	
15	14·4	11·9	19·8	17·9	

Oxford.

Digitized by Google

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Month of October, 1856.

(*Communicated by the Astronomer Royal.*)

Hygeia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Oct. 20 7 16 46·8	21 14 29·62	102 37 33·05
22 7 9 34·9	21 15 9·75	102 35 18·38

Fortuna.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Oct. 1 11 46 14·7	0 29 47·33	85 35 21·61
13 10 49 18·3	0 20 0·18	86 49 29·06
21 10 9 14·6	0 14 49·33	87 33 32·09
30 9 33 24·1	0 10 54·93	88 10 44·93

Eunomia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Oct. 27 10 7 38·0	0 33 24·80	63 19 44·81
28 10 3 5·0	0 32 47 58	63 27 50·08

Thalia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Oct. 13 12 14 12·5	1 45 8·34	91 39 31·79
21 11 34 58·4	1 37 20·19	92 2 7·22
27 11 5 32·5	1 31 28·81	92 13 47·36

Massilia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Oct. 21 12 46 40·5	2 49 14·08	73 57 31·36
25 12 27 25·2	2 45 41·90	74 15 12·08
27 12 17 42·2	2 43 50·39	74 24 21·80

Digitized by Google

Melpomene.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Oct. 21 12 34 41·4	2 37 13·01	95 7 25·25
27 12 6 42·2	2 32 48·60	95 58 10·74

Oct. 21. It is doubtful whether the object observed is the planet.

On the Projection of Stars on the Disk of the Moon.

By Capt. W. S. Jacob.

"I have now to communicate a veritable case (or rather two cases) of projection of stars on the moon's face, the first that I have seen quite satisfactorily; for though I have often noticed something of the kind, there has generally been some defect of definition, or other ground for suspecting the accuracy of the observation.

"In the present instance, I was waiting for the immersion of 23 *Tauri* on the 18th instant. The sun had just risen, and there was a thick haze, so that the star was rather dim; but I saw it plainly enough. The moon's limb advanced and touched it, but the star did not disappear; it continued to advance till the star was entirely on the moon's face, and then suddenly disappeared, several seconds after contact with the limb. The immersion of η followed about an hour later; the daylight was stronger, but the haze had somewhat cleared, and the star being intrinsically brighter, I saw it much better than 23; the same phenomenon as before was repeated. My impression at the time was, that the star advanced rather *more* than its whole breadth on the moon; but on reflection immediately after, I could not be *quite* sure that I had seen any part of the moon *outside* of the star; but certainly the whole light of the star was on the moon. Irradiation can hardly be admitted in the present instance, the observation being made in daylight.

"On the 21st I saw one of *Jupiter's* satellites for the first time with the naked eye; I have often looked for them before, but without success. *Jupiter* was shining very bright and clear, with little radiation; I looked at him with an eyeglass—a single lens, of long focus, and plainly saw a small point near him, and could get glimpses of it with the naked eye. My sight is not very good without glasses. To make sure there was no delusion, I asked a person who was with me, 'Do you see anything unusual about *Jupiter?*' 'Yes, there is a small star almost touching him below.' 'Is it exactly below?' 'No, a little to the left;' which was the true position. The satellite was the third, which was the largest of the four, and was near elongation. With the eyeglass, I had a

Digitized by Google

suspicion of another, nearer the planet; and on examination there were found the first and second, near together, whose united light may have slightly impressed my vision.

"*Observatory, Madras, 26th September*, 1856."

Annular Solar Eclipse, September 18th (*Greenwich*, 17^{d}), 1857. By J. F. Tennant, Lieut. Engineers, 1st Asst. Gt. Trig. Survey of India.

"The accompanying table has been circulated, as far as I have been able, among those likely to furnish observations; but as I can find few of the Fellows, perhaps you would admit it in the *Monthly Notices* for more extensive circulation among parties likely to be interested. The computations have been verified by a brother officer.

Calculated Positions of the Central and Limiting Lines for the Annular Appearance within Indian Longitudes.

Southern Limit.		Central Line.		Northern Limit.	
Lat. N.	Long. E.	Lat. N.	Long. E.	Lat. N.	Long. E.
° ′	° ′	° ′	° ′	° ′	° ′
35 28·7	66 59·4	36 5·4	67 17·2	36 42·5	67 34·3
34 10·2	70 50·0	34 45·1	71 9·8	35 20·3	71 28·9
32 51·0	74 4·7	33 24·3	74 25·8	33 57·6	74 46·8
31 32·2	76 52·4	32 3·9	77 14·7	32 35·7	77 36·9
30 13·8	79 19·6	30 44·1	79 42·9	31 14·5	80 6·1
28 55·7	81 31·0	29 24·5	81 54·9	29 53·6	82 18·8
27 38·1	83 29·0	28 5·7	83 53·6	28 33·2	84 18·1
26 20·6	85 16·3	26 47·0	85 41·3	27 13·7	86 6·4
25 3·4	86 54·6	25 28·9	87 20·0	25 54·4	87 45·4
23 46·4	88 25·5	24 11·1	88 51·0	24 35·5	89 17·0
22 30·4	89 49·7	22 54·0	90 15·6	23 17·7	90 41·5
21 14·2	91 8·4	21 37·1	91 34·5	22 0·0	92 0·7
19 58·4	92 22·6	20 20·5	92 48·9	20 42·7	93 15·3
18 42·8	93 32·9	19 4·3	93 59·3	19 25·9	94 25·7
17 27·5	94 39·9	17 48·6	95 6·3	18 9·8	95 32·8
16 12·3	95 44·1	16 33·0	96 10·6	16 53·5	96 37·2
14 57·1	96 46·0	15 17·4	97 12·6	15 37·6	97 39·2
13 42·8	97 46·6	14 2·5	98 13·1	14 22·5	98 39·7
12 27·4	98 45·4	12 47·4	99 11·9	13 7·3	99 38·5
11 12·6	99 43·2	11 32·5	100 9·9	11 52·3	100 36·6

N.B.—Observations with the true times and geographical position of the place will be very acceptable.

"*Masuri, September 15th*, 1856."

Digitized by Google

Observation of α Centauri. By Capt. W. S. Jacob.

"This is my last mean for *α Centauri.*

	Position.	Distance.	
1856·591	310°·54	3″·882	Mean of 5 days' observations.

"The minimum dist. appears to be past.

"*Observatory, Madras,* 11 *Sept.* 1856."

Two papers by W. Simms, Jun. Esq.— one on the Corrections to be applied to Observations with the Sextant, the other, Formulæ for the Determination of Latitude by Means of Observed Transits of Stars near the Prime Vertical — were also read. Abstracts of these will appear in the next number.

Mr. Warren De La Rue has sent for distribution copies of an engraving of the planet *Saturn* for 1856, the epoch of the greatest opening of the rings. Application for copies is to be made to the Assistant-Secretary at the Apartments of the Society.

ERRATA, VOL. XVI.

Page 155, *dele* the observation of *Lætitia*, on March 31, and the foot-note to that on March 26.

— 217, in the observation of *Eunomia*, on Sept. 4. *read* App. R.A., $1^h\ 12^m\ 13^s{\cdot}27$, *for* $1^h\ 12^m\ 10^s{\cdot}87$.

— 219, *dele* the observation of *Hygeia*, on Sept. 29.

— 224, 8th line from top, *for* $1^h\ 42^m\ 2^s{\cdot}208$ east, *read* $1^h\ 42^m\ 22^s{\cdot}08$ east.

Digitized by Google

CONTENTS.

	Page
Fellow elected	1
Observation of Occultation of *Jupiter* by the Moon, by Mr. De La Rue ...	ib.
Ditto Ditto by Mr. W. Huggins ...	2
Ditto Ditto by Mr. T. W. Burr ...	ib.
Dttio Ditto by Mr. W. R. Grove ...	3
Ditto Ditto by Mr. J. F. Goddard	4
Ditto Ditto by Lord Wrottesley ...	ib.
Observation of a Lunar Occultation of *Jupiter's* fourth Satellite, by the Rev. W. R. Dawes	ib.
Observations of *Jupiter* during October, 1856, by Mr. De La Rue	5
Telescopic Appearance of *Saturn* during the Apparition of 1855–6, by the Rev. W. R. Dawes	7
Note on the Division of the Outward Ring of *Saturn*, by Mr. Hartnup ...	10
Note accompanying Drawings of *Saturn*, by Capt. Jacob	ib.
Note on the Observations of *Antares*, by Mr. Hippisley	11
Magnitudes of Thirty-six of the Minor Planets for the first day of each month of the year 1857, by Mr. Pogson	12
Results of Observations of Small Planets made at the Royal Observatory, Greenwich, communicated by the Astronomer Royal	16
On the Projection of Stars on the Disk of the Moon, by Capt. Jacob ...	17
Annular Solar Eclipse, Sept. 18, 1857, by Lieut. Tennant	18
Observation of α *Centauri*, by Capt. Jacob	19
Miscellaneous	ib.

London:—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, December 11, 1856.

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *December* 12, 1856. No. 2.

MANUEL J. JOHNSON, Esq., President, in the Chair.

Frederick John Evans, Esq. R.N., Superintendent of the Compass Department, Admiralty,

was balloted for and duly elected a Fellow of the Society.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, chiefly in the Month of November, 1856.

(*Communicated by the Astronomer Royal.*)

Melpomene.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 8 11 10 20·9	2 23 36·70	96 57 58·84
14 10 42 50·0	2 19 40·56	97 5 29·91
27 9 46 13·8	2 14 10·39	96 32 0·57
29 9 37 58·1	2 13 46·46	96 21 58·45

Fortuna.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 14 8 23 26·8	0 9 56·14	88 35 25·08
27 7 47 8·0	0 14 44·99	88 18 2·15

Digitized by Google

Eunomia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 14 8 50 38·8	0 27 11·01	65 50 48·67
27 8 1 51·4	0 29 30·80	67 26 37·57
29 7 54 51·2	0 30 22·60	67 39 7·40
Dec. 3 7 41 12·8	0 32 28·10	68 1 56·79

Massilia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 14 10 49 40·9	2 26 32·60	75 53 46·23
29 9 39 35·9	2 15 24·53	76 54 14·52
Dec. 1 9 30 42·6	2 14 22·85	.....

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 5 13 14 9·9	4 15 56·34	59 37 56·71
14 12 30 1·6	4 7 9·78	59 33 43·83
27 11 24 40·4	3 52 53·16	59 51 3·79
28 11 19(39·3)	.....	59 53 26·88
29 11 14 38·8	3 50 43·03	59 55 57·95
Dec. 1 11 4 39·1	3 48 34·76	60 1 20·78

Lutetia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1856, Nov. 5 14 5 7·2	5 7 2·03	68 26 35·22
28 12 12 (58·8)	.....	68 32 51·42
29 12 7 59·8	4 44 12·73	.....

It is very doubtful whether any of the above places are those of the planet *Lutetia*.

Digitized by Google

Note accompanying Drawings of Jupiter, Mars, &c.
By Wm. Huggins, Esq.

"I send herewith two drawings of *Jupiter* for Oct. 14th and 15th. On each occasion the planet was watched for a considerable time, but no change of appearance or of relative position was observed in the markings on the belts, except that due to *Jupiter's* rotation.

"Also, two drawings of the planet *Mars* for April 28th and May 19th.

"Also, a coloured drawing of the lunar eclipse of Oct. 13th, 1856, to show the *deep blue* colour of the *edge* of the umbra, which, for a short time before and after the greatest observation, was in strong contrast with the copper colour of the remainder of the Moon's surface. Gleams of silver-grey light were noticed from time to time to light up partially the dark-blue edge of the umbra. They appeared as if thrown very obliquely upon the Moon from the east.

"*Upper Tulse Hill.*"

On Variable Stars. By Norman Pogson, Esq.

(*Communicated by the President.*)

The ready response which the proposal for a division of labour in the case of observations of the small planets has recently met with, induces me to hope that a similar arrangement may be made with equal facility for the variable stars. Little is yet known of many of these curious objects, in consequence of the small number of observers who have devoted their time to the subject, and it is only by continuous observations that we can expect to trace to fixed laws the often capricious changes which some of these bodies undergo. To facilitate such observations during the ensuing year, I have deduced, from the best available sources, the most probable times of maxima of most of the long-period variables, also the conveniently observable minima of six short-period stars. I have been obliged to omit many of the former class, and even the well-known variable β *Lyræ*, for want of trustworthy elements on which to base their ephemerides. Most of the minima of S *Cancri* in 1857 will, unfortunately, occur at very inconvenient hours. I am indebted to Joseph Baxendell, Esq., of Manchester, for the periods and epochs of the two variables discovered by him, viz. λ *Tauri* and 13 *Lyræ*.

Professors Argelander and Heis, Dr. Schoenfeld, and M. Schmidt, appear to have occupied themselves mostly with the older variables, especially with o *Ceti*, *Algol*, ι *Aurigæ*, ζ *Gemi-*

Digitized by Google

norum, S *Cancri*, R *Virginis*, *α Herculis*, *β Lyræ*, *χ Cygni*, and *δ Cephei*. Some time since Professor Oudemans signified his intention of watching the telescopic variables discovered by Mr. Hind. Doubtless he will also take care of his own recent discovery, S *Tauri*, as Dr. Luther has hitherto done of his S *Piscium*. Mr. Baxendell has authorised me to state that he has for some years past observed, and will in future hold himself responsible for observations of λ *Tauri*, *α Herculis*, *β Lyræ*, 13 *Lyræ*, *χ Cygni*, *η Aquilæ*, Herschel's *Garnet Star*, and *δ Cephei*. Lastly, I have adopted as my own charge R, S, T, and U *Geminorum*, R *Leonis*, R and S *Ursæ Majoris*, S *Virginis*, S and R *Ophiuchi*, R *Cygni*, 24 *Cephei* (*Hev.*), and R *Cassiopeiæ*.

While writing upon the subject, I take the opportunity to make the following general remarks:—Very few of the variable stars increase and decrease with equal rapidity; hence the time of maximum cannot be deduced by taking the mean between two dates of equal brightness before and after such maximum. I find the most simple and expeditious method to be that of projection on cross-ruled paper, making the abscissæ represent days, and the ordinates magnitudes, to tenths. A curve traced through observations thus projected gives the best general idea of the march of variation, and of any flexures which may occur in the increase or decrease. With the exception of *β Lyræ*, most of the short-period variable stars are tolerably regular, and vary more rapidly about minimum than near maximum. One star, U *Geminorum*, discovered by Mr. Hind in Dec. 1855, is exceedingly curious. For upwards of 90 days it remains invisible,—increases to maximum (9th mag.) and again disappears in about a fortnight, and a day or two after maximum shows remarkable unsteadiness or twinkling which I have not observed with other variables. Next to U, perhaps S *Geminorum* is the most rapid in its visible changes, and remains invisible for the greatest fraction of its period. Its neighbour, T *Geminorum*, is much slower in its changes, though its whole period is a few days shorter than that of S. R and S *Ursæ Majoris* are remarkably regular as regards time of maximum, though less so in intensity of light. R rises with astonishing rapidity to maximum, but fades away very slowly, while S is the most equal in duration of increase and decrease of any variable I know. Others again are very irregular, especially *o Ceti*, R *Leonis*, S *Virginis*, R *Coronæ*, *α Herculis*, R *Scuti*, and R *Cassiopeiæ*. The star 24 *Cephei* (*Hev.*), if periodical, cannot complete its changes in less than 73 years, which makes it due as a naked-eye star about 1880. It has certainly increased during the last 7 years. The red, or rather scarlet tint, is very decided in many stars at maximum. I have noticed it chiefly in R *Cassiopeiæ*, R *Leonis*, and S *Virginis*, which are all irregular stars: in others, as R *Ursæ Majoris*, R *Cygni*, and U *Geminorum*, no change of colour has been perceived. Some stars which do not disappear are hazy and indistinct at minimum, as if surrounded by a corona, or seen out of focus; others are sharp and point-like at such time. So various

Digitized by Google

are the appearances presented by these mysterious stars, for whose changes no plausible hypothesis has ever yet been suggested.

Variable Star Maxima in the Year 1857.

Star.	Probable Mag.	Mean Place in 1860. R. A.	N. P. D.	Date of Maxima.
		h m s	° ′	
T Piscium	9·5	0 24 46	76 20	About the end of July or beginning of Aug.
α Cassiopeiæ....	2	0 32 35	34 14	Jan. 9, Mar. 29, June 16, Sept. 3, Nov. 21.
R Piscium	7·5	1 23 25	87 50	Early in June.
ο Ceti.....	2·3	2 12 17	93 37	1856, Dec. 30; 1857, Nov. 30.
R Tauri.....	8	4 20 38	80 9	1856, Dec. 20; 1857, Nov. 10.
R Orionis	9	4 51 22	82 5	Either Jan. 31, or April 23. (Period still uncertain.)
ε Aurigæ	3·5	4 51 56	46 23	Feb. 14; Oct. 22.
α Orionis	1	5 47 36	82 37	Early in April, and about middle of October.
R Geminorum ..	7	6 58 56	67 5	Jan. 2; and 1858, Jan. 7.
R Canis Minoris	8	7 1 0	79 45	April or May.
S Geminorum ...	9	7 34 38	66 14	Jan. 5, and Oct. 27.
T Geminorum ...	9	7 40 54	65 55	Aug. 5.
U Geminorum...	9·3	7 46 48	67 38	March 4, and October 15. Only visible for about a fortnight.
R Cancri	6	8 8 57	77 53	February or March.
S Hydræ.....	8·5	8 46 15	86 24	March 19, and Dec. 4.
T Hydræ.....	6·5	8 48 51	98 37	January and September.
R Leonis.....	5	9 40 2	77 55	Near the end of July, and therefore not observable.
R Ursæ Majoris	7·5	10 34 41	20 29	May 14. (Minima, Jan. 19, and Nov. 17.)
R Virginis.....	6·5	12 31 24	82 14	March 25, and Aug. 17.
S Ursæ Majoris	7	12 37 48	28 8	April 20, and Nov. 28. (Minima, Jan. 11, and Aug. 20.)
R Hydræ.....	4	13 22 5	112 33	Possibly early in February, but uncertain.
S Virginis	5·5	13 25 42	96 28	March 29. Changes of colour very decided.
S Serpentis	8	15 15 8	75 11	June 26.
R Coronæ	6	15 42 49	61 25	Very uncertain, but perhaps in May.
R Serpentis.....	6·5	15 44 15	74 26	Nov. 8, and therefore not observable.
S Ophiuchi	9·3	16 26 12	106 53	May 15.
R Ophiuchi.....	8	16 59 44	105 54	October 4.
α Herculis.....	3	17 8 16	75 27	April 14, June 19, August 24, and Oct. 30. Very irregular.
R Scuti	5	18 40 1	95 50	April 18, June 29, and Sept. 8. Also very irregular.
13 Lyræ	4·3	18 51 4	46 14	Jan. 8, Feb. 23, Apr. 11, May 28, July 13, Aug. 29, Oct. 15, and Nov. 30.
R Aquilæ	6·5	18 59 40	81 59	Probably early in August.
R Cygni	8	19 33 4	40 7	Feb. 14. (Minimum, Oct. 23.)
χ Cygni.....	5	19 41 7	56 36	December 27.
R Pegasi	8·5	22 59 38	80 13	August 15.
R Aquarii	7	23 37 15	106 3	July 27.
R Cassiop. (2nd)	6	23 51 18	39 23	1858, Jan. 30. (Minimum, 1857, Aug. 21.)

Digitized by Google

Minima of Short-period Variable Stars in the year 1857, for the Earth's Mean Distance from each Star, and Greenwich Mean Times.

Algol.
Max. 2·3. Min. 4·0.

		h	m
Jan.	2	9	28
	5	6	17
	19	14	21
	22	11	10
	25	7	59
Feb.	11	12	52
	14	9	41
March	6	11	23
	9	8	12
	29	9	54
April	21	8	25
May	28	15	0
June	20	13	31
July	13	12	2
Aug.	2	13	44
	5	10	33
	25	12	15
	28	9	4
Sept.	14	13	57
	17	10	46
	20	7	35
Oct.	7	12	28
	10	9	17
	27	14	10
	30	10	59
Nov.	2	7	48
	19	12	41
	22	9	30
	25	6	19
Dec.	9	14	23
	12	11	12
	15	8	1

λ Tauri.
Max. 4·0. Min. 4·5.

		h	m
Feb.	4	12	37
	8	11	29
	12	10	21
	16	9	13
	20	8	5
Oct.	7	14	9
	11	13	1
	15	11	53
	19	10	44
	23	9	36
	27	8	28
	31	7	20

δ Cephei.
Max. 3·7. Min. 4·8.

		h	m
Jan.	15	14	5
	26	7	40
Feb.	11	10	3
	27	12	26
Mar.	15	14	49
	26	8	24
April	11	10	47
	27	13	10
May	24	9	9
June	9	11	32
	25	13	55
July	22	9	53
Aug.	7	12	16
	23	14	39
Sept.	19	10	37
Oct.	5	13	0
Nov.	1	8	59
	17	11	22
Dec.	3	13	45
	14	7	20
	30	9	43

η Aquilæ.
Max. 3·6. Min. 4·4.

		h	m
May	3	13	59
June	8	11	9
July	21	12	32
Aug.	26	9	42
Sept.	2	13	55
Oct.	8	11	5
Nov.	13	8	14
Dec.	19	5	24

ζ Geminorum.
Max. 3·8. Min. 4·5.

		h	m
Jan.	16	8	1
	26	11	36
Feb.	5	15	11
March	28	9	3
April	7	12	38
Aug.	27	14	41
Oct.	27	12	8
Nov.	6	15	42
Dec.	27	9	35

S Cancri.
R.A. $8^h\ 35^m\ 56^s$
N.P.D. 70° 28′
Max. 8·0. Min. 10·5.

		h	m	s
Jan.	16	8	57	
Feb.	4	8	10	
	23	7	24	
Dec.	14	7	29	

Digitized by Google

The observed times of Minima of short-period Variables require to be reduced to what they would have been at the earth's mean distance from the star, to render them comparable with each other, or with the above ephemerides. The following formulæ will supply these corrections, with their proper signs, in minutes of time, for each star; the earth's radius-vector and sun's longitude being denoted by R and ⊙ respectively:—

For Algol	...	...	...	$7^m\cdot67$	R	sin	(215 47′	+ ⊙)
λ Tauri	...	...	...	8·22	R	sin	(211 19	+ ⊙)
δ Cephei	...	...	...	4·21	R	sin	(254 19	+ ⊙)
η Aquilæ	...	...	...	7·72	R	sin	(331 31	+ ⊙)
S Cancri	...	...	...	8·30	R	sin	(143 38	+ ⊙)
ζ Geminorum		...		8·29	R	sin	(166 58	+ ⊙)
β Lyræ	...	...	...	4·64	R	sin	(343 4	+ ⊙)

On the Correction of Observations made with the Sextant. By W. H. Simms, Esq., communicated by William Simms, Esq.

The object of this communication is to demonstrate the practicability of correcting sextant observations for the instrumental error of excentricity;—an error, which probably exists in most sextants, and to such an amount that the maximum correction to an angle read from the arc is seldom less than 30″, and not uncommonly exceeds 1′.

The author commences by investigating the formula for the computation of the correction, the relative position of the centres of the index and arc being given. This relative position depends upon two constants, which enter into the formula: consequently, two or more absolute values of the correction being known, the constants can be determined. Such absolute values can be obtained in any number by comparing the results of observation of distances of well-known stars with their computed distances; or, at a place of which the latitude is known, by observation of meridian altitudes of similar objects. The latter method is undoubtedly the better and more convenient, and may be employed at a place of which the latitude is unknown, the latitude itself being introduced as a third unknown quantity into the equations resulting from the observations.

But, in order that this process may be applied with success, it is evidently necessary that the results of the observations should not be materially affected by any instrumental error other than excentricity. The author accordingly investigates the formulæ for the calculation of the corrections due to the remaining three principal errors to which the sextant is liable, viz. deviations of the planes of the index and horizon glasses, and of the optical axis, from their correct positions with respect to the plane of the instrument;—and shows that, if ordinary care be taken in the

Digitized by Google

performance of the requisite adjustments, such of these errors as are likely to exist in a good instrument will not sensibly affect the results. The investigation is given at length in the case of an error in the position of the horizon glass, the formulæ only being given in each of the other cases, as well as in a combination of the three; this having been thought sufficient as an indication of the process. The results of these investigations are satisfactory, not only with reference to their immediate object—the demonstration of the fact that excentricity is the only instrumental error which, under ordinary circumstances, produces sensible effects—but as showing that small accidental disturbances of the horizon glass, such as frequently take place in the course of a series of observations, are unimportant, provided they do not affect the index error.

Having shown that the results of observation are sensibly affected by error of excentricity alone, the author proceeds to explain in detail the processes by which the values of the two constants, which enter into the formula for the computation of the correction may be determined; and concludes, by giving examples of their determination, and of the construction of tables of corrections for various positions of the index upon the arc.

A note is appended to the communication containing details relative to the determination of index errors.

On the Latitude of the Liverpool Observatory, deduced from Observations made with a Transit Instrument placed in the Prime Vertical, by means of Formulæ given by W. H. Simms, Esq.

In vol. xiii., No. 8, of the *Monthly Notices* of the Society, is a communication by Mr. Hartnup, on the latitude of the Liverpool Observatory, from observations made with a transit-instrument placed in the prime vertical. The formulæ used for the reduction of the observations, as stated in that paper, were obtained from Mr. W. H. Simms, who was at that time resident at Colombo, in Ceylon.

Mr. Simms, being now in England, has communicated to Mr. Hartnup his investigations in a revised shape, and has given the formula for deviation from the prime vertical in a more convenient form, and, at the same time, has introduced the effect of an error of collimation on the results, which was neglected in his former communication. With these new formulæ, he has calculated the corrections for deviation and collimation for the whole series of observations previously employed in deducing the latitude; and Mr. Hartnup has taken the opportunity of making a fresh determination of this element. The whole number of

Digitized by Google

transits formerly employed was 58, but of these it has appeared desirable to reject 4; and, from the remaining 54, the latitude deduced by means of the new formulæ is 53° 24′ 47″·40, with a probable error of 0″·10. This result is less by 0″·32 than that given in vol. xiii. of the *Monthly Notices*.

The number of stars employed is sixteen; and, for each of these, Mr. Hartnup has given, in a tabular shape, the values of the constants required in the use of the formulæ; and, in a second table, he has given the individual result derived from every transit of each star, together with the values of the errors of deviation and collimation for each evening, and the corrections which they entail on the results.

This communication, as well as the preceding, will appear in full in the *Memoirs*.

On a Proposed Mode of relieving the Weight of the Moving Portion of an Altazimuth, and on the Theory of the Stability and Pressure exercised by the Upper Works. By Lieut. J. F. Tennant, Bengal Eng., F.R.A.S, First Asst. Gt. Trig. Survey of India.

"The form of altazimuth instruments of which I purpose writing, is that in which the whole of the azimuthal axis is below the vertical circle. These are generally supposed to be less stable and less adapted for very accurate observation than those in which the vertical axis is divided and held both at top and bottom, the telescope and vertical circle being between the two supports. My attention has been especially directed to the class of instruments I have named, as that form is alone suited to theodolites for Geodetical operations, and has led to a similar construction of altazimuths for the trigonometrical survey of India.

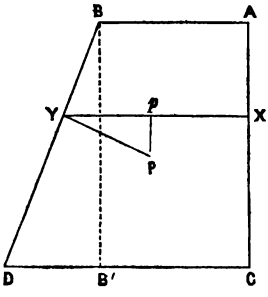
"Instruments of this form may be subdivided into two classes, of which the first has the axes *turned down* (the acute end down), and the second* has them *turned* up. The former construction allows of a long axis, while the height of the instrument is not increased, and has been employed for this reason, as length of axis appears to ensure steadiness; but I shall, I think, show reason for preferring the second construction, or that with a moderately long turned up axis.

"I purpose first considering the distribution of weight on an axis supposed to be composed of two conical portions, whose vertical angles are different, and shall first investigate the amount of weight which will be supported on a right cone with the axis vertical by a given pressure on each unit of its surface.

* An illustration of this construction will be found in Pearson's *Int. to Practical Ast.*, Plate xix.—EDITOR.

Digitized by Google

"Let the accompanying figure represent the trapezoid, by whose revolution about A C the frustrum of a right cone forming the axis is generated. Let



$$A B = a = C B', \quad C D = b, \quad A C = l,$$

and the angle $D B B' = d$.

"Also let $A X = x$, $X Y = y$.

"Also let Y P represent the pressure sustained by the element of the surface, whose sides are d (B Y) and $y\, d\theta$ (to use the infinitesimal notation).

Now $B Y : A X :: B D : A C :: 1 : \cos \alpha$,

$$\therefore B Y = x \sec \alpha,$$

and $$d(B Y) = \sec \alpha\, d x.$$

"And if p be the pressure per square unit of surface, then $P Y = p \,.\, y \sec \alpha\, d\theta\, d x$, and the resolved part in a vertical direction, or the weight it will support, is

$$P p = P Y \sin \alpha = p \,.\, y \tan \alpha\, d\theta\, d x,$$

but if we suppose the whole frustrum to be in action, the supported weight will be

$$\int_0^l \int_0^{2\pi} p \,.\, y \tan \alpha\, d\theta\, d x$$

or since $y = x \tan \alpha + a$

$$= \int_0^l \int_0^{2\pi} p \left\{ x \tan^2 \alpha + a \tan \alpha \right\} d\theta \,.\, d x,$$

$$= p \int_0^{2\pi} \left(\frac{1}{2} l^2 \tan^2 \alpha + a l \tan \alpha \right) d\theta$$

$$= 2 p \pi \left(\frac{l^2}{2} \tan \alpha + a l \right) \tan \alpha$$

But $l \tan \alpha + a = b$, and $l \tan \alpha = b - a$

$$\therefore \text{weight} = p \pi (b + a)(b - a) = \pi (b^2 - a^2) p$$

whence if W be the total weight supported by the frustrum, we shall have

$$p = \frac{W}{\pi (b^2 - a^2)}$$

or it will have the same value as it would have were a similar weight supported on the base of the inclined surface in action.

"I have supposed the pressure to be uniformly distributed over the acting surface, which would, I conceive, be the case had we a true mathematical frustrum; and I think this will, in a

Digitized by Google

well-made axis, be an approximate representation of the case. We are not, however, entitled to consider that, if we have two frustra (the angle β in the second being substituted for α) simultaneously in action, that the pressure on the surfaces will be equal in both.

We can, of course, adjust this to some extent as we may please originally, but the adjustment will only be permanent, if the pressure on the frustrum, the angle of whose cone is 2α (which I shall call the frustrum 2α), be to the pressure on the frustrum 2β in the proportion requisite to ensure wear keeping the same state of fitting. Now, the amount of wear on the frustrum 2α will be to the amount of wear on the frustrum 2β as $\sin\alpha$ to $\sin\beta$, when this state is attained; and if we assume that the wear is proportional to the pressure, an assumption which, in default of positive data, seems to be probable, we shall have

$$P_{\alpha} \text{ (or pressure on frustrum } 2\alpha) : P_{\beta} :: \sin\alpha : \sin\beta$$

" If there be a flange, or $\beta = 90^{\circ}$,

$$P_{\alpha} : P \text{ on flange} :: \sin\alpha : 1$$

" Let us, on this supposition, assume $p \sin\beta$ as the surplus pressure on the more obtuse cone, then will $p \sin\alpha$ be that on the more acute one; and we shall have, calling A and B the bases of the acting surfaces,

$$p\,A \sin\alpha + p\,B \sin\beta = W, \text{ the free weight,}$$

but P the total pressure causing friction

$$= p \sin\alpha \,.\, A \operatorname{cosec}\alpha + p \sin\beta \,.\, B \operatorname{cosec}\beta \text{ or } p\,(A + B)$$

whence,

$$P = W \frac{A + B}{A \sin\alpha + B \sin\beta}$$

which, when α is a very small angle, as is usual, will very nearly equal W cosec β.

" This explains the theory of the flange and Ramsden's cup in rendering motion free, which would otherwise be so stiff as to be objectionable.

" Keeping in view these principles, we may, from a knowledge of the co-efficient of friction derived from experiment, predict the force which would be sufficient, at the place where the hand is intended to be applied, in moving the instrument to cause it to revolve.

" Where this force is too large, it becomes necessary to relieve a portion of the weight of the moving part. So far as I am aware, this has hitherto been accomplished by springs, and by counterpoising weights acting on levers; friction rollers in each case being the mode of transmitting the action to the upper works. Variable tension at different times, and consequently irregularly applied relief, is an objection to springs; and, moreover, from the

Digitized by Google

necessary shortness, they generally have to be very stiff, and small differences of compression are correspondent to material pressures. These are avoided by counterpoises, but they add to the weight of the instrument; and where (as in theodolites) the instrument travels, they must be previously removed, of which perhaps the inconvenience can only be appreciated by those who have had to dismantle and pack up instruments late at night, when wearied with a long day's work. In either case, want of power to render the resultant transmitted pressure *axial* is a great objection, and it does not appear that this can be accurately managed.

"It seems absolutely essential to the good performance of an instrument of the class I am examining, that the resultant of the weight of the moving portions and relieving springs should be *axial*, as otherwise there will not be fair action on the axis; and the simplest way of attaining this would appear to be, to make the weight and relieving force each axial separately. I also think that a low position of the centre of gravity, such as will enable it to be *immediately supported* by the axis, and thus secure the instrument against any great tendency to oscillatory motion, is at all events very advisable.

"The weight of a telescope and vertical circle, and the height to which they must be raised to allow of reversion of the telescope, is no doubt an obstacle to carrying out the last principle; but we can still lower the centre of gravity within the axis, by turning up the axis and using a very heavy drum, to which the only objections I know are the want of portability and the difficulty of sufficiently reducing friction. The former is of less importance than the steadiness of the instrument, and the latter, I believe, can generally be sufficiently relieved by the means I am about to mention.

"I propose, then, to adapt to the upper part of the hollow conical axis a shallow reservoir for oil, having a narrow cylindrical tube rising out of it, in which works a piston urged by a weight. The reservoir is to be open downwards, by which pressure will be transmitted by the oil to the head of the solid cone, and the same pressure will assist in lubrication. We may then make this pressure relieve any amount of weight within the limits I shall point out, and at the same time secure its rigorously axial application.

"If the free weight be m W, p the pressure on the unit of the flange, and $p \sin \alpha$, therefore, that on the conical frustrum before the relief is applied, or while the weight is W, then $mp \sin \alpha$ will be the pressure on the relief being given, unless the pressure on a unit of surface on the head of the axis be greater than $mp \sin \alpha$, when the whole surface of the frustrum will come into play, and we must consider the relieving pressure as acting on the area of its base.

"It is quite evident, however, that if q be the relieving pressure on a unit of surface, mp must be $> q$ as a necessary condition

Digitized by Google

to prevent the expulsion of the oil when the capillary action which retains it is overcome. In cases where there is no flange, the pressure on the unit of surface of the cone will have to exceed that on the head for the same reason, and if the necessary relief cannot be given with the given dimensions of the axis, it can of course in this case be attained by increasing its dimensions.

"How far attention to these principles will secure stability in conjunction with freedom of motion, it is impossible to say without putting them in practice, but I hope soon to have an opportunity of carrying them out in endeavouring to obtain a better azimuthal motion for one of the 3-foot vertical circles belonging to the trigonometrical survey of India, which, though producing results of the highest order, would still admit of an improvement. I am induced to offer these remarks to the Society, in the hope that the hydraulic relief may be an improvement on those previously in use, and that by it a class of instruments in which I am professionally much interested may be rendered more perfect.

"I have not attempted to lay down any rules as to the dimensions of axes or their forms. So many variables are involved in the determination of the best form, and a departure from it to a moderate extent will so little affect the value of instruments, that probably no definite rules could be so valuable as the intuitive perception of the practised artist. I believe, however, the general principles I have here laid down, and the theory to guide their application, will occasionally be found useful, and they may tend to place the form of instrument preferred by Mr. Troughton on equal terms with that chosen by some other makers, by increasing the steadiness without the disadvantage of unequal expansions inseparable probably from the framework required to support an axis at both extremities.

"In the case of the 3-foot circle I propose that the drum pillars and micrometer-supporters should be cast in one piece of iron, and, after being fitted, adjusted so as to have the centre of gravity axial by floating the mass in mercury, and adding or subtracting small weights of metal, as may appear desirable.

"*Masuri, June* 4, 1856."

Notes on the Manufacture of Tubes for Refracting Telescopes.

By Frederick Brodie, Esq.

"In the early part of this year I parted with my Munich refractor of 6½ inches clear aperture, and obtained from the Rev. W. R. Dawes his American object-glass, made by Mr. Alvan Clarke, of Boston, U. S., an account of which was published in the *Monthly Notices*, vol. xv. page 79.

"The original tube for this glass was retained by Mr. Dawes for mounting another larger object-glass, by the same maker. It,

Digitized by Google

therefore, became a matter of consideration with me to procure a tube which should combine strength, rigidity, and lightness, being convinced in my own mind, that the less the weight of the tube (and consequently of its counterbalances), the greater would be the steadiness and freedom from vibration when mounted on its equatoreal stand.

"I was led to this conclusion by the experience which I had had with my 8½-foot Munich refractor, with its light wooden tube, and in which, when fixed on my peculiar equatoreal mounting, I had never found the slightest oscillation or tremor, when moved either by hand or the tangent-screw motion. This great steadiness I attribute to two principal causes:—Firstly, to the loading of the polar axis with as little weight as possible. Secondly, to the fact that the polar axis has comparatively large bearings.* In several mountings of large telescopes that I have seen, where the polar axes have been loaded with brass tubes and heavy circles, and where the bearings (or pivots) have been comparatively small, I have noticed a very considerable amount of oscillation in right ascension.

"After some consideration I determined on constructing the tubes entirely of mahogany veneers; veneers cut from deal would have been lighter than those from mahogany, but they were not considered so trustworthy for this purpose. I placed the execution of this experimental tube in the hands of Mr. Chaffins, of 67 Oxford Street, who carried out my directions satisfactorily.

"This tube was formed upon a core of dry, well-seasoned deal planks, and turned down in the lathe to the following dimensions:—

Length of core	.....	9 ft. 0 in.
Diameter, large end	.....	..... 7⅞
Do. small end	.....	..... 5⅞

"The core was well soaped to prevent the possibility of any portion of glue adhering to it, and thereby rendering the removal of the tube difficult when finished. Upon the core a sheet of thick brown paper was wrapped, its edges being pasted together, to serve as a foundation for the first veneer. The core was then brushed over with glue, and a veneer of mahogany laid round it; a moveable caul made of double canvas was then laid round the veneer, and drawn up tightly by means of screws.

"This caul exactly fitted the taper of the tube, and its longitudinal edges were securely fastened to two strips of wood. In one of these strips, at intervals of about 5 inches, were inserted common bed-screws, moving freely through it, and screwing into

* The size of the bearings of the polar axis cited above was as follows:—

Lower bearing	.....	4 inches diameter.
Upper do.	.....	3¼ do.

Digitized by Google

corresponding nuts in the other strip. By this means the caul was screwed up tightly round the veneer, thereby ensuring a close contact between it and the core.

"The core was then placed over a stove-pipe, which extended along its whole length, and was slowly turned on its axis until it became sufficiently hot to melt the glue, which thus became equalized, while the superabundant quantity was squeezed out; a portion even permeating the veneer, owing to the pressure of the caul. The core was then set aside for two or three days to dry.

"Every successive veneer, prior to being laid on, was lined with a piece of thin calico, to prevent the veneer from splitting while being turned round the core. This calico was removed when the veneer was dry; after which the surface was prepared for another veneer, by being levelled over and freed from inequalities by the veneer plane. Each veneer was in a single piece, the joints being placed at alternate sides of the tube, and the grain of the wood was reversed at every layer. A tube was thus formed of eight thicknesses, the seven interior ones being of Spanish mahogany having stains or other faults which rendered them unfit for *fine* cabinet work, and therefore of moderate cost (about 9*d.* per foot super). The eighth was of the finest Spanish mahogany, and cost (on account of its great size) about 1*s.* 8*d.* per foot super. The thickness of tube when finished was $\frac{1}{8}$ of an inch. It was French polished on the outside.

"Since this tube has been finished another tube has been constructed in a similar manner, and sufficiently stiff, of only *six* veneers. The dimensions being,

Length of tube	6 ft.	8 in.
Inside diameter, large end		$6\frac{1}{8}$
Do. small end		$4\frac{1}{4}$

"The tube which was sent over from America by Mr. Alvan Clarke is of a novel construction, it being made of a sheet of zinc covered with brown paper. This tube is still in the possession of Mr. Dawes, and carries an 8-inch object-glass. It is only $\frac{5}{10}$ths of an inch in thickness, but is remarkably solid and hard to the touch.

"The method of making these tubes is thus described by Mr. Clarke in a letter to the Rev. W. R. Dawes:—

"'We made our tube for that (telescope), as we have for others since, of thin tin, overlaid with paper and paste, to a suitable thickness. By drawing a thread from end to end we find out the low parts, and raise them by an extra coat of paper, and at the same time rasp down the higher parts until tolerably straight. We then joint a piece of plank and coat it with wax, and lay sand-paper upon it; with this we dress down the tube preparatory to painting. We give several coats of different tints, blue, red, and yellow, all faint, but of the same depth when dry; they are rubbed down together. The effect is very pleasing to the eye, and I think, under

Digitized by Google

copal varnish, this tube must be very secure. For the larger object-glass which you have, zinc was used instead of tinned iron.'

"The Munich tubes appear to be made of two thicknesses of light wooden battens, about $2\frac{1}{2}$ inches wide, and of the same length as the tube itself. These battens are laid longitudinally round a core, the inner thickness breaking joint with the outer; over this is laid a veneer of mahogany, which is finally French polished.

"The relative weights and thicknesses of the different tubes are as follows:—

	Thickness of Tube.	Weight of Tube.
Brass or iron tube	0·06 to 0·10	3 to 5 lbs.
		lbs. oz.
Square deal, corners champered off	1·00	2 8
American tube, paper and zinc	0·20	1 $10\frac{1}{2}$
Mahogany tube, 8 veneers thick	0·37	2 1
Do. 6 veneers thick	0·28	1 $8\frac{1}{2}$"

Specimens of the tubes described accompanied the paper.

On the Angular Disturbances of Ships, as affecting Astronomical Observation at Sea. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.*

"Every one who has used a telescope on shore knows the importance of steadiness in its stand; and nearly every one in this nautical country must have experienced in person how ships roll, and pitch, and lurch at sea; upsetting all ideas of stability, even for the ordinary affairs of life, and much more for scientific requirements. On inquiring, however, from even practical men, I have not found them able to give me numerical particulars of the exact amount, and the manner of the occurrence, of these angular disturbances of position, which occur to a ship while pursuing its onward course; and as some knowledge of this is essential before attempting to devise a remedy, we may with propriety first consider the means of obtaining this information.

"*Measurement of the Disturbances.*—All the various angular motions to which any ship is liable, the translation of the whole ship bodily being of no moment here, are reducible to three, viz., —to *rolling*, a motion from side to side; *pitching*, from end to end; and *yawing*, or deviating in azimuth.

"*Old Ship-Clinometers.*—Very ingenious methods have been contrived to fit pendulums to act as ship-clinometers, as in Captain Becher's horizon; wherein the pendulum swings in a vessel of oil. But the result is not satisfactory; for the oil itself is dis-

* Reduced, by permission, from a paper lately presented to the Society of Arts at Edinburgh. The woodcuts have been very kindly lent by the Society.

Digitized by Google

turbed, and while the pendulum's tendency to vibration is not got rid of, its sensibility to angular motion is impaired.

"Troughton, again, employed a most elegant method; for, constructing a pendulum of a circular form, like an inverted cup, he set this spinning at a great velocity; and then for a time it seemed to bid defiance to any disturbances in the absolute position of what it rested on, while it showed the angular movements well. Soon, however, the defect predicted by an astronomer became practically apparent, viz., that the forces producing vibration in a simple pendulum were still at work in this rotatory one, and these effects compounded into the spinning movement, at length produced precessional disturbances, which entirely destroyed the accuracy of the indication.

"*New Clinometer.*—For ship purposes, then, we need something that shall be barely influenced by horizontal, but shall be very sensible to angular displacement. Now, this necessary quality of sensibility existing, as is well known, to a high degree in spirit-levels, I first tried modifications of these for naval purposes. The bubbles of air were certainly liable to vibrate after the style of the pendulum by linear movements; but they came to rest almost immediately after the disturbing force had ceased; and a little reflection on the reason of their first movement, immediately made me perceive that it might be reduced indefinitely by decreasing the size of the bubble, and this I found true in practice. But then came the difficulty, that with very small air-bubbles the friction or retardation of their movements greatly increased. A series of experiments, however, on different fluids, indicated that with chloroform the desiderated qualities existed in a sufficient degree for practical purposes, the amount of resistance to movement of small bubbles therein being about $\frac{1}{3}$d of that in ether, $\frac{1}{18}$th of alcohol, and $\frac{1}{100}$th of water.

"*Safety-Level.*—There then remained only to contrive some plan of safety, by which, in a hermetically sealed glass tube (for no other will confine chloroform) a very small bubble might be employed, without a chance of fracturing the glass when the liquid should expand at a high temperature. This object has been attained by introducing a pierced diaphragm into the tube

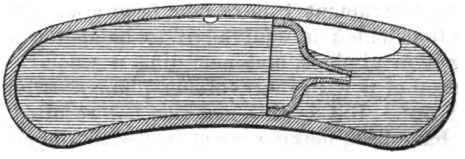


Fig. 1.

Sectional Elevation of the Adjustable Minim Bubble-Level.

near one end, and confining therein a large quantity of air, which serves as a safety-valve for the fluid from the rest of the tube

Digitized by Google

to press upon when expanding. In ordinary motions of the level, the air does not change its compartment, but when it is held vertical and shaken smartly, small particles of the air may be made to pass from one side to the other of the diaphragm; and thus the bubble may be adjusted in size at pleasure. Mr. John Adie has made many of these levels for me with consummate skill, and finds that to be the best kind of diaphragm or plug which is made of glass and fitted with floss silk.

"*Application to Ship Purposes.*—To apply this principle to a clinometer for use at sea, I have had such a safety chloroform level made to a radius of 6 inches, and an arc of 180 degrees. Being further fitted into a wooden frame with a greyed-glass back, having the angles painted thereon, the smallest bubble is clearly visible, and it will be found to possess, not perfect, but a very high degree of freedom from the effects of horizontal displacement, with, at the same time, an eminent degree of sensibility to angular motion.

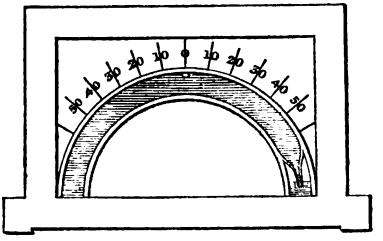


Fig. 2.

Sectional Elevation of the New Ship Clinometer.

"*The Rotation Clinometer.*—The level clinometer, however, does not indicate azimuthal disturbances; and though sufficient and very convenient for most practical purposes, a more perfect instrument is conceivable—one that shall be positively undisturbed by even the most violent lurches, and that shall measure yawing as well as pitching and rolling.

"Such an instrument I have now been able to bring forward, by a proceeding which is equivalent to balancing a Troughton's top, placing it in gimbals, and mounting a second similar apparatus on the top of it with its revolving plane crossing the other at an angle of 90°. But as this machine has resulted from the researches I have been making connected with the *elimination* of a ship's movements, presently to be described, I shall only now say that its action as a *differential* instrument for a short space of time is wonderfully perfect. The rolling is shown on one circle, the pitching on another, and the yawing on a third; and any features in which the level-clinometer may fail, are the strongest points in this instrument. For, while absolutely uninfluenced by horizontal

Digitized by Google

displacement, however quick, or violent, or unexpected, still it has not thereby its sensibility to angular motion injured in the smallest degree; and, in a word, it may confidently be said to be entirely free from the defects which have been described to exist necessarily, to more or less extent, in all pendulums, fluids, or in gravitation appliances generally.

"*Elimination of the Disturbances. Methods hitherto in vogue.*—When an object, for instance a small table, is to be kept level at sea, there is but one method at present employed, viz., to suspend it freely, either in gimbals like a chronometer, or by strings from a hook, as with the trays over a cuddy-table.

"But plainly by such a proceeding we should not have approached the qualities of a table-stand for astronomical instruments; and as long as we have free suspension of any sort above, and a weight below, we may be sure that our arrangement is but a pendulum, which, as described in the case of the clinometer, must, when at sea, be ever oscillating anomalously; and, therefore, being unable to keep itself steady, it can never on ship-board keep a table so. Yet this was the only principle of Nairne's celebrated observing-chair, which, though rewarded by Government, utterly failed in practice.

"*Neutralization of Vibrations.*—Free suspension, however, of some kind we must have, or our table will be carried over bodily and forcibly with the ship; but let us first try to get rid of oscillations, the effect of horizontal displacements, and afterwards we may more successfully cope with the angular motion. To this end, knowing that a pendulum will swing, we shall find it salutary to hang it from its centre of gravity. Then, with a free suspension still, but with as much matter above as below it, the pendulum is changed into a balanced body; and the lurches of the ship, acting on the two halves with an equal force, but in opposite directions, are completely neutralized. In principle this method is simple and perfect; and in practice, with a model apparatus, consisting of a small table mounted on double gimbals and balanced, the correction is so complete that if the fixed frame be taken in the hand, and violently shaken, no vibration or particular disturbance is occasioned. But when a small weight is hung below, the least motion of the outside supporting-frame occasions a pertinacious oscillation of the internal gimbals carrying the table.

"*Elimination of Angular Movements.*—We have thus got rid of the effects of horizontal displacement, and of *lurching*, but the effect of angular motion still remains; for it will be found, on tilting the outside fixed frame above described, that the whole of the internal parts tilt over too, and have no power of themselves to maintain any one position more than another. The human hand is continually needed to put them right. When it is considered that a ship is never at rest, not even for the tenth part of a second, it is plain that we must look to some much more efficient means than the hand of man, to effect our purpose; something that will

Digitized by Google

in fact correct for the motion of the ship while it *is* taking place, and before it *has* taken place.

"*The Spinner, or Free Revolver Stand.*—On clearly making out to myself, two years ago, the nature of this difficulty, it occurred to me to try for its correction the principle that enables the earth so steadily to keep its pole pointed to one invariable part of the sky while it is being annually swung round the sun, and exposed to so many disturbing forces, which are yet not able sensibly to prevail against it. This principle, the persistence of a free axis of rotation, combined with the composition of rotatory motion, was also particularly known to me by Troughton's Top, or Spinning Pendulum, before alluded to, and by the writings of the Rev. Baden Powell.

"Introducing, therefore, into the internal gimbals of the already-described balanced apparatus, a smoothly and rapidly revolving wheel, and balancing it also on the gimbal pivots, and placing its plane horizontal, I had the satisfaction of finding that it was perfectly efficacious in defending the table from any pitching or rolling motion that could be given to its supporting frame, quick or slow, short or long.

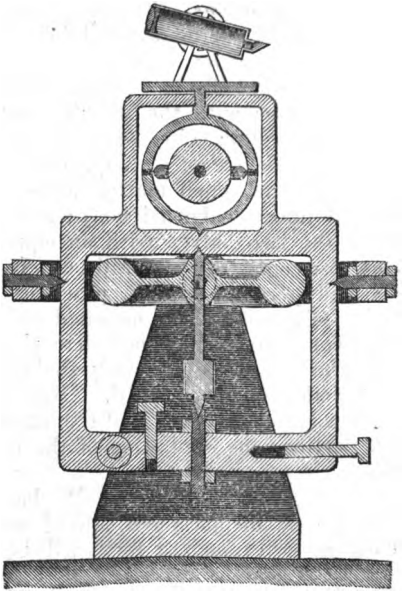


Fig. 3.

Sectional Elevation of Simple Revolver Stand.

"The single spinner apparatus described above, though fully able to protect from all disturbances at right angles to its plane,

Digitized by Google

cannot protect from any that coincide with it. But having, by its means, obtained a small platform, which, once put level by hand, keeps itself so, we may on that erect a second spinner in gimbals with its plane vertical; and balancing this on its own gimbals, and also on those of the first spinner, we may then employ its power to protect from azimuthal movements a table or a telescope placed on its outer gimbal ring.

"Such table will then be entirely defended from all the possible angular movements of a ship; and a telescope once directed on a star, will keep it in the field without hand, though the ship may pitch and roll and yaw to any extent. And if the telescope be moderate in size, and the eye-piece not far from the centre of motion, and its lens large, an observer would have no difficulty in following its apparent motions, with his eye, really rolling with the ship, and so might keep up uninterrupted observation with a high magnifying power.

"*Driving the Spinners.*—Having now a stand with wheels, and it being necessary to make them as large and heavy as possible, something more powerful than a train of wheel-work, impelled by the hand, is necessary to drive them, and to get up a speed, be it remembered, which is unprecedented in mechanics.

"Let it be laid down at once that our driving-power for the wheels must come from a steam-engine, by endless band, or by water, or by steam-pipe.

"With an endless band there will be difficulty in getting up the necessary speed, on account of the slowness of the first mover in a steam-engine. Intervening wheels and pinions multiply expense, vibration, and friction, and, after all, are not so extensively available for multiplying speed excessively as the motion of fluids pressed out of large tubes into small ones; as an extreme case of which may be taken the boiler of a steam-engine with some thousand times the area of the steam-pipe through which all the steam is conveyed away.

"This method I have therefore experimented on in the case of water, air, and steam. The same means employed to utilize one will also suit the others; but air and steam are capable of producing much more velocity than water for the same pressure; and of the two aëriform drivers, steam is the more easily applied, as it can be brought to bear at once out of the boiler by a pipe without the intervention of pump machinery. The steam indeed at first proved troublesome, by its heat and moisture, on escaping after it had done its work, but it was soon found quite possible to carry off all this waste by a second steam-pipe placed in a small wooden chimney communicating with the box in which the driving apparatus was contained.

"*Elemental Driving applied directly to the Spinner.*—To gain this end I have made many experiments, and have concluded with a small turbine on a pin which is fixed into the lower spinner pivot, and projects through its bearings. In the normal position of the apparatus the turbine hangs down in the inside of the sup-

Digitized by Google

porting-stand or table; the steam or water pipe, fitted with a peculiar nozzle, is then raised so as to enter the void centre of the turbine, and flashes out the fluid in a horizontal sheet through the curved and open sides. The vanes forming these sides are purposely set nearly at right angles to the radii, in order to make the speed of revolution surpass the rate of efflux, and appears in a transverse sectional plan, as in fig. 4.

Turbine Driver.
Sectional Plan.

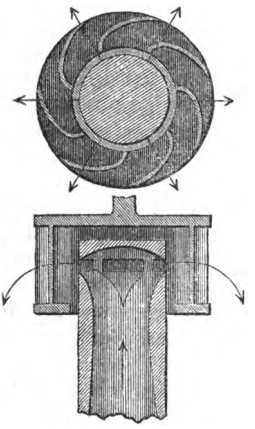


Fig. 4.
Sectional Elevation of the above.

"The power of this method is so great that the wheel moves the instant the steam is applied, the full velocity is obtained in but a few seconds, and the addition of the 10 lb. spinner hardly affects the rate of revolution of the 4 lb. turbine, which is about 70 to 80 per second.

"*Conclusion.*—With these powerful elemental methods of driving, and with large wheels at high velocities, there seems no reason why platforms should not be constructed for use on ship-board capable of carrying both the observer and his telescope.

"Tremor might be feared, because we find it more or less wherever we find mill-wheels revolving; but that is because their centre of gravity is not adjusted symmetrically to their axis of motion. In our case we do employ accurate methods of effecting this important correction, and we may expect, therefore, the large wheels to revolve as smoothly and as silently as the small ones."

The following paragraph appears in the *Boston Daily Evening Traveller* of October the 22d:—

"We understand that George P. Bond, Esq., who was recently appointed by the President, with the consent of the Senate, Chief Astronomer of the United States, under the Act of Congress of August 11th, 1856, to carry into effect the first article of the Treaty of June 10th, 1846, between the United States and Great Britain, by running the boundary line between America and British Oregon, has declined the appointment.

"Mr. Bond is the first assistant at the Astronomical Observatory of Harvard University at Cambridge, and by this decision meets the strongly expressed wishes of the friends of the Observatory, and of its Director.

"We also understand that this nomination was made by the

Digitized by Google

President, without any consultation with Mr. Bond, and solely on account of the high reputation he has acquired as an Astronomer. It was, therefore, an appointment equally honourable to the President and (to the) recipient thereof."

Extract of a letter from Mr. G. P. Bond, dated November 7, 1856:—

"We are preparing, on a large scale, for renewing experiments in lunar photography.

"Before this reaches you, you will probably have received Part i. of vol. i. of our *Annals*, completing the first volume . . . The subject of Part i. vol. ii. will be mostly *Saturn*, of which we have eight years' observations of physical aspect," &c.

At the conclusion of the ordinary business of the meeting, Mr. Carrington gave a verbal account of a recent short tour of inspection into the present state of some of the German observatories; premising his statement with the remark that it would greatly tend to keep our information of what other observers are engaged in up to date if other Fellows of the Society would, after autumn travels, in like manner communicate what they had had opportunities of ascertaining. The observatories visited were those at Bonn, Bilk, Göttingen, Gotha, Leipsic, Halle, Dessau, Berlin, Hamburgh, and Altona. Mr. Carrington was requested to put his remarks into a form suitable for the *Monthly Notices;* and will, in this paper, endeavour to comply with the wish expressed.

Woodcut representations of several of the above-named observatories will be found in a little tract entitled *Deutschland's Vorzüglichste Sternwarten*, written and published by Carl von Littrow, as an appendix to his Calendar for the year 1848, and sold separately. A copy was presented, and laid on the table.

At Bonn, Dr. Argelander, and his assistants, Drs. Schoenfeld and Kreuger, are now principally engaged upon a large series of zone observations of stars for basis-points of an extensive system of charting. The whole northern hemisphere has been divided into zones of two degrees width by one hour in length, to be gone over twice, the zones of the second series overlapping those of the first by one degree. The positions are being observed with a small equatoreal of less than three inches aperture, with a species of comb *painted* on a plate of glass in the focus; and the work is much of the quality of the Markree observations made with a similar object. Of about 2000 zones required, 1300 are completed, and a trial-chart (scale double the Berlin) lithographed. The Professor confines his own attention more particularly to the continuation of his researches connected with variable stars,

Digitized by Google

and to the measurement of double stars, with a very fine heliometer mounted in the principal central tower.

The observatory at Bilk was built in 1844, by a Dr. Benzenberg for his own use, and was at his death, about two years after, bequeathed to the town of Düsseldorf. Dr. Brünnow, now of Michigan, was stationed here for about three years, and on his return to Berlin at the end of the year 1851, was succeeded by the present Director, Dr. Luther. Dr. Luther is engaged in the observation and discovery of minor planets, preparing for publication one of the remaining charts of the Berlin Academy, filling in and extending Argelander's southern zones, and computing ephemerides. He possesses a very fine comet-seeker of five French inches aperture, provided with the so-called autoscopic eye-pieces, constructed by Kellner of Wetzlar, near Frankfort. These eye-pieces consist of three lenses, the first a large double convex lens placed before the focus, and the other two small, united with Canada balsam, and forming an object-glass combination. With a power of 15, the observer has a good field of four degrees. Kellner himself is now dead, and his widow carries on his business.

Books or communications of any size are most conveniently and rapidly received by Dr. Luther, if addressed in the first instance to Dr. Argelander; and the best mode of transmission to Bonn is through Mr. Otto Marcus, bookseller, of 8 Oxford Street, London, whose father is one of the principal booksellers in Bonn.

At Göttingen, Dr. Klinkerfues continues to be the resident astronomer; Professor Dirichlet, the geometer, having succeeded Gauss as director. One of the instruments here has now principally a historical interest,—the quadrant of Tobias Mayer. The chief instrument in use is a Reichenbach meridian-circle, employed on a partial revision of Piazzi's Catalogue; the instrument most used, perhaps, being the comet-seeker with which Dr. Klinkerfues has already discovered five comets.

The channel of transmission to Göttingen is through a London foreign bookseller to the firm of Dietrich.

One principal object in the writer's visit to Göttingen was to obtain a sight of the MSS. in which are contained Dr. S. T. Sœmmering's observations of the solar spots; but, after a search, in which he was much assisted by Mr. Wagner and Professor Listing, he found that he was under a wrong impression, and succeeded in tracing them to the Senkenberg institution at Frankfort.

At Gotha, a new observatory in the south suburbs of the town is in progress of erection, which is designed to take the place of the former one on the Seeberg hill, about a mile to the south-east. The Seeberg Observatory has been pulled down, and its materials have been used in the construction of the new one. The instruments are meanwhile placed in a small building attached to the dwelling-house of Professor Hansen, where Mr. Carrington was permitted to examine a modification of the method of circle-reading and provision for the determination of division-errors proposed by Professor Hansen in Nos. 388 and 389 of the *Astronomische Nachrichten*. Present

Digitized by Google

space does not permit the insertion here of a description of the arrangement adopted, but readers of German will find it repay them to refer to the article named, and will, perhaps, be the more induced to attend to the recommendation on being informed that Professor Peters has recently substituted this arrangement for that which was before in use at Altona, and that a transit-circle for Albany, now in the hands of Pistor and Martins, is likewise being so fitted. The lunar tables on which the Professor has been so long engaged had very recently been finished and forwarded to England for publication.

In another part of the town of Gotha was a private observatory belonging to Professor Habicht, provided with the usual transit and equatoreal; and, in addition, with one of Repsold's universal instruments. These small instruments are capable of doing very delicate work in skilful hands, are moderate in cost (40*l.* to 60*l.*), and from their adaptability to a variety of purposes, are, perhaps, better suited than any others for the introduction of students to the first leading processes of practical astronomy.

The observatory at Leipsic is probably the most singularly situated of any now existing. In the south-west angle of the fortifications of the city there is an extensive barrack, from which rises a cylindrical tower, of more than 150 feet in height, of about 40 feet interior diameter, and with walls of 10 feet in thickness, termed the Tower of the Schloss Pleissenburg. At a height of some 120 feet, the tower contracts on the outside, leaving a railed balcony of about 5 feet in width, and from thence rises in the form of a dome, surmounted by a lantern. At the level of the balcony, narrow sheds have been built on to the side of the tower for a transit and other instruments; and the telescope with which Professor D'Arrest has made his observations of nebulæ and comets, is mounted on a tripod, which is run out on wheels to any part of the balcony required, the ring-micrometer being of necessity used in all cases. Professor D'Arrest stated, that a removal was contemplated to a more suitable and less elevated situation in the outskirts of the city. A notice of some of the recent labours of Professor D'Arrest will be found elsewhere in the present number.

At Halle there is a small observatory situated in the Botanical Garden, consisting of an octagonal tower of three stories, provided with balconies, and, adjoining it, on the ground-floor, is a moderate-sized meridian-room. The transit-circle was at the maker's, undergoing repairs. The instrument for more general use is a Fraunhofer telescope of 52 lines ($4\frac{1}{2}$ inches) aperture, on a tripod stand; but for this Professor Rosenberger remarked that the building afforded no sufficiently firm support.

At Dessau, Mr. Carrington paid a visit to the Hofrath Schwabe, whose house is situated in the St. Johannis-Strasse. The observatory, for so it may be rightly termed, consists of a small attic, some 12 feet by 10, with four small windows overlooking the roofs of adjoining houses. From this little room a Fraunhofer

Digitized by Google

telescope, equatoreally mounted at one of the south windows, has, for thirty-one years, been almost daily directed to the sun, and by its means the spots observed on its surface have been recorded regularly in a series of quarto volumes, with appended diagrams, which now form a considerable collection, and one which excites no little interest in the beholder from the singleness of aim, continuity of purpose, and success with which their author has laboured upon them. Mr. Schwabe is now sixty-seven years of age, and still continues his accustomed occupation.

A full description of the Observatory at Berlin, with plans, is given in the first volume of Professor Encke's *Observations*. The writer was principally struck with the large refractor, mounted in Fraunhofer's manner, and with the perfection of the shutter-machinery in the meridian-room. Professor Encke is assisted at the present time by Dr. Forster and Mr. Carl Bruhns, who find the observation of the minor planets and comets with the great refractor as much as their united force can profitably be extended to.

At Hamburgh, a new equatoreal tower of considerable dimensions is nearly completed. It stands in the rear of the dwelling-house, and detached from it. The interior diameter of the dome, which is of metal, is 20 feet clear. The instrument is not yet constructed, but it is intrusted to Mr. Repsold, and intended to exceed 9 inches in aperture. When mounted, it will be the principal instrument of the Observatory. At present, Mr. George Rümker is engaged in observing the minor planets with the equatoreal so long used by his father; who, since his severe accident, has been unable to take any further active part in the work of the Observatory.

At Altona, Professor Peters has been introducing the use of Hansen's auxiliary sectors and moveable microscope-frame in the reading of the transit-circle, raising the equatoreal tower to obtain a better horizon, and building a set of rooms adjoining his own house for the residence of his assistant, M. Pape. In other respects the Observatory and grounds presented nearly the same appearance which they did during a former visit, in the year 1851, to the late Professor Petersen. Professor Peters was intending to apply the meridian-instrument, in the next place, to the determination of the positions of a limited number of circumpolar stars. Astronomers know what to expect in that case from this consummate manipulator and analyst.

Book-parcels may generally be forwarded directly to Gotha through a foreign bookseller; otherwise, for Gotha, Leipsic, and Halle, the Weidmannsche Buchhandlung at Leipsic is the best centre of delivery.

Similar parcels for Hamburgh and Altona are best sent by the same channel to Messrs. Perthes, Besser, and Mauke of Hamburgh, with whom both Observatories have dealings.

All requisite information concerning letter postage for the above, and probably all other Observatories, may now be found

Digitized by Google

in sections 7 and 9 of the *British Postal Guide*, lately published by the authority of the Postmaster-General.

Mr. Carrington has, in the foregoing sketch, abstained from all allusion in passing to an inspection of the large Bürger-schule of Leipsic, which he was most kindly allowed to make by their present learned Director, Dr. C. Vogel, the father of Dr. Edward Vogel, now travelling in Africa; to a visit of a like nature to Mr. Repsold's factory in Hamburgh; as well as to an interview with the Baron von Humboldt, which he had the high honour and gratification to be favoured with at Potsdam. He fears, on reviewing what he has written, that, in the attempt at extreme condensation, much matter of interest has necessarily been boiled away; but he trusts that readers of the paper will allow that it is simply impossible to give an adequate description of nearly a dozen different establishments in the compass prescribed.

Much information of a like nature, concerning the present American Observatories, with the advantage of woodcut illustrations, will be found in the *third* edition (recently published) of Professor Loomis's *Recent Progress of Astronomy, especially in the United States.*

The attention of the Fellows is called to a small octavo volume of 110 pages, by Mr. J. F. Julius Schmidt, entitled *Das Zodiacallicht.* In this work Mr. Schmidt gives numerous observations of estimated right ascensions and declinations of points in the north and south bounding lines of the cone of light, as seen by him at different times during the years 1843 to 1855. The first section contains a notice of the labours of his predecessors in the subject. The second contains the observations and accompanying remarks, arranged chronologically. The third contains the equivalents of the preceding observations, converted into latitude and longitude, for intervals of 10° or 20° longitude, after removing surface discordances by a process of curving and interpolation. In this section the data are arranged in the order of months and days, without regard to the year. Mr. Schmidt then proceeds to a discussion of his results, assembling them first for that purpose into eight groups, with a mean date. He finds a variation in the inclination of the axis of the cone of light to the ecliptic, from 4° 18′ at the end of December to zero towards the end of March; a similar variation in the greatest elongation from the sun, from 120° in January to 70° in April; and a further similar variation in the breadth at corresponding elongations: the totality indicating a minimum for all three at about the 30th of March. By continuing backwards to the longitude of the sun the north and south bounding lines of each day's observation, he finds a mean breadth at that part of about 50 times the sun's diameter. The fourth and last section is devoted to an inquiry into the possible connexion of the phenomenon with the resisting medium round

Digitized by Google

the sun. We do not aim to do more than give an idea of the contents of Mr. Schmidt's little book, leaving it to those who have paid more attention to the subject to say what degree of reliance can be placed on results of this nature; but we are very glad to see systematic observation and careful induction brought to bear on this field of inquiry.

Another work which we have to notice is the first series by Professor D'Arrest of his *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen*, published in the *Transactions* of the Royal Society of Saxony. This work contains about 600 observations of 230 nebulæ, made with a double-ring micrometer of Fraunhofer's construction, applied to a refracting telescope of 52 lines aperture, or rather more than 4½ English inches. Professor D'Arrest states in his preface, that he considered it would not be a superfluous undertaking to lay a basis for subsequent inquiry into the possible relative motion of the nebulæ and fixed stars, by connecting them by observation at the present time with stars from the zones of Bessel and Argelander. He remarks that he has been astonished to find, as his work proceeded, how large a number (probably nearly a thousand) of these objects were within the reach of his very moderate-sized instrument. His plan has been to make repeated observations in as many cases as possible of the nebulæ admitted into his list, and to confront them with the older positions, brought up to date, of Lacaille, Messier, Mechain, Oriani, the two Herschels, and Laugier. Of new nebulæ he has met with only three or four, of which not more than two could be classed among the brighter ones. He proceeds to an inquiry into the comparative errors of individual observations of the older authorities, and then into the probable errors of his own results, and concludes with stating that, although in two or three cases there appear differences of sensible amount between the ancient and modern observations, the differences are so few and moderate that they may rather be attributed to some error in the older observation. A catalogue of Sir W. Herschel's nebulæ of the first and fourth classes, brought up to 1850, is given at the end.

Star-Charts.

The Society has recently received, from the Imperial Observatory at Paris, the first six numbers of a series of seventy-two Ecliptic Charts, laid down by M. Chacornac. The scale is about 2¼ English inches to the degree, or rather more than four times that of the Berlin Academy Star-charts. They are filled in to the thirteenth magnitude, and the relative magnitudes are distinguished by the size of the dot denoting the position. The date of the last comparison of each chart with the heavens is added,

Digitized by Google

a practice which we recommend for adoption. The engraving and general execution is singularly beautiful, and we should not fear to hold them up as a model of representation for the imitation of others engaged in the like work.

A second edition of Harding's *Atlas* has lately appeared, under the editorship of Dr. Jahn. It is stated in the title that the maps have been much improved by the assistance of several astronomers, which will doubtless give them an increased value to the observer. The price of the maps in London is *2l. 5s.*

There has also been recently published a single sheet, about 8 feet in length by 2 feet in width, entitled *Die Æquatorialzone des gestirnten Himmels, entworfen von Prof. Dr. J. Müller (Freiburg, Fr. Wagnersche Buchhandlung)*, on which the stars visible to the naked eye within the zone from 50° north to 40° south declination, are laid down in white on a dark purple ground. The boundaries of the constellations are marked with dotted red lines. The price is trifling, *4s.* This sheet may be found useful for the lecture-room, and very possibly for something more.

A drawing of *Mars*, by Mr. R. Hodgson, was exhibited, which confirms the observations of Mr. De La Rue and Capt. Jacob.

Mr. J. G. Barclay has sent a drawing of *Mars*, made in April 1856, and two drawings of *Jupiter*, for Nov. 21, 1856.

The Astronomer Royal, who at all times evinces an earnest desire to smooth the difficulties of the astronomical inquirer, has placed a liberal supply of copies of the Results of the Greenwich Observations at the disposal of the Fellows.

Mr. Hind, the Superintendent of the *Nautical Almanac*, has also sent several copies of the Ephemerides of the Minor Planets for 1857, for distribution among the Fellows. Application to be made to Mr. Williams, the Assistant-Secretary, at the Apartments of the Society.

ERRATA.

Vol. XVI., p. 128, *Polyhymnia*, Jan. 15 / Feb. 12 } *dele* the results.

The Planet was not observed.

Vol. XVII., page 2, line 3, *for* $4^h\ 22^m\ 26^s{\cdot}9$, *read* $4^h\ 42^m\ 26^s{\cdot}9$.

Digitized by Google

CONTENTS.

Page

Fellow elected 21

Results of Observations of small Planets made at the Royal Observatory, communicated by the Astronomer Royal ... ... ib.

Note accompanying Drawings of *Jupiter*, *Mars*, &c., by Mr. Huggins ... 23

On Variable Stars, by Mr. Pogson ... ... ib.

On the Correction of Observations made with the Sextant, by Mr. W. H. Simms 27

On the Latitude of the Liverpool Observatory, deduced from Observations made with a Transit Instrument placed in the Prime Vertical, by means of Formulæ given by Mr. W. H. Simms 28

On a proposed Mode of relieving the Weight of the Moving Portion of an Altazimuth, and on the Theory of the Stability and Pressure exercised by the Upper Works, by Lieut. Tennant, Bengal Eng. 29

Notes on the Manufacture of Tubes for Refracting Telescopes, by Mr. Brodie 33

On the Angular Disturbances of Ships, as affecting Astronomical Observation at Sea, by Prof. Piazzi Smyth 36

Appointment of Mr. G. P. Bond to be Chief Astronomer of the United States, and declined by him 42

Extract of a Leter from Mr. G. P. Bond 43

Account of a recent short Tour of Inspection into the Present State of some of the German Observatories, by Mr. Carrington ... ... ib.

Notice of *Das Zodiacallicht*, by Mr. J. F. Julius Schmidt 47

Notice of *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen*, by Prof. D'Arrest 48

Star-charts ... ... ib.

Miscellaneous 49

London:—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, January 9, 1857.

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *January* 9, 1857. No. 3.

MANUEL J. JOHNSON, Esq., President, in the Chair.

Joseph Baxendell, Esq., Manchester;
J. Masters Share, Esq. R.N., Tynemouth;
Capt. John Vine Hall, Southampton;
Wm. Bolger Gibbs, Esq., Camberwell;
Lieut. Jos. Dayman, R.N.;
Geo. Andrew Rogers, Esq., 2 Park Villas, Highbury Grove;
Capt. A. S. H. Lowe, Highfield House, Nottingham;

were balloted for and duly elected Fellows of the Society.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Month of December, 1856.

(*Communicated by the Astronomer Royal.*)

Melpomene.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
1856, Dec. 13 $8^h\ 43^m\ 47^s\cdot8$	$2^h\ 14^m\ 39^s\cdot01$	$94^\circ\ 36'\ 38''\cdot46$

Eunomia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
1856, Dec. 10 $7^h\ 18^m\ 33^s\cdot6$	$0^h\ 37^m\ 21^s\cdot11$	.....

Digitized by Google

Massilia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
1856, Dec. 13 h m s 8 40 6·3	h m s 2 10 56·96	° ′ ″ 77 20 3·68

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
1856, Dec. 26 h m s 9 7 29·9	h m s 3 29 40·33	° ′ ″ 61 29 6·43

Occultation of Jupiter by the Moon, on Oct. 12, 1856, *as observed at Madras.* By Captain Jacob.

Instrument—the 6·25-inch equat. power 174, throughout.

			Madras Sidereal Time. h m s	
Dark limb,	4th Sat.	first contact	23 34 16·7	
		disappearance	23 34 19·7	(*a*)
	Jupiter,	first contact	0 1 42·1	(*b*)
		disappearance	0 5 0·7	
	1st Sat.	disappearance	0 6 54·0	(*c*)
	2d Sat.	disappearance	0 15 22·4	(*c*)
	3d Sat.	first contact	0 24 41·1	(*d*)
		disappearance	0 24 50·6	
Bright limb,	Jupiter,	reappearance	0 46 11·4	(*e*)
		last contact	0 49 16·6	
	1st Sat.	last contact	0 49 17·6	(*f*)
	2d Sat.	last contact	0 50 24·7	
	3d Sat.	last contact	0 52 4·8	

(*a*) The satellite vanished and reappeared for an instant. Its light shone very dimly (like a kind of twilight) just at the last.
(*b*) The moon's limb, as seen upon *Jupiter*, showed several projecting points. *Jupiter* finally disappeared in a hollow; so that the last portion visible was triangular.
(*c*) First contact could not be caught.
(*d*) Uncertain to 1ˢ or 2ˢ.
(*e*) Late 1ˢ or 2ˢ; *Jupiter* being very dim at first appearance. No distortion visible either at immersion or emersion; but the last portion of all the satellites (at immersion) seemed to hang for an instant on the limb, and was very dim. The same was noticed of *Jupiter*, though in a less degree.
(*f*) First appearance could not be caught.

Digitized by Google

Occultation of the Pleiades by the Moon, on Nov. 12, 1856, *as observed at Madras.* By Capt. Jacob.

			Madras Sidereal Time. h m s	
n	Tauri	disappearance	7 17 48·2	(*a*)
23	—	reappearance	26 50·2	
1176	B. A. C.	disappearance	34 24·2	
27	Tauri	disappearance	48 24·2	(*a*)
n	—	reappearance	48 44·2	(*b*)
28	—	disappearance	58 42·2	
1188	B. A. C.	disappearance	8 4 28·2	(*c*)
1186	—	disappearance	6 46·2	(*c*)

Interrupted by clouds and rain. Moon very near the full. Power employed, 114.

(*a*) The star seemed to slide on to the moon, but was not distinctly visible on its face. Sky hazy, with flying clouds.
(*b*) Doubtful to about 1ˢ, being hurried from the previous observation.
(*c*) Uncertain to 2ˢ or 3ˢ, the stars being dim through the haze.

Occultations of Stars by the Moon, observed at Highbury. By T. W. Burr, Esq.

The following occultations in the year 1856 have not been previously reported:—

		Mag.		Local Sid. Time. h m s	
Jan. 12	27 Piscium	5	Immersion	1 16 39·9	Dark limb.
			Emersion	1 33 4·4	Bright limb.
March 13	136 Tauri	4½	Immersion	8 19 23·9	Dark limb.
			Emersion	9 31 7	Bright limb.
July 25	τ^2 Arietis	6	Immersion	20 48 23·9	Bright limb.
			Emersion	20 59 57·9	Dark limb.
	65 Arietis	6	Immersion	21 10 56·9	Bright limb.

The immersions of τ^2 and 65 *Arietis* are rather uncertain. The first ran along the edge of the lunar crescent for some seconds, rendering the moment of disappearance doubtful, and the latter was affected by the boiling and bad definition of the moon's limb. The other observations are good.

Notice of his Solar-spot Observations. By R. C. Carrington, Esq.

It is pretty generally known that during the past two years the surface of the sun has exhibited a comparative state of quiescence, the outbreaks of spots being few and often far between, and the spots themselves for the most part small. The Redhill observations, however, indicate that the epoch of least action is now passed, and as they appear to fix the date of the minimum with

Digitized by Google

some degree of certainty, it is thought that the following numbers may not be without interest. In the first column is given the number of days on which spots were seen on the disk in each month; in the second, that on which no spots were found; and in the third, the percentage of spot-days to days of observation, as a measure of frequency. The fourth column contains the means of successive numbers in the third, and the fifth the means of those in the fourth.

	Spots.	No Spots.	$\frac{(1)}{(1)+(2)}$			
1855, Jan.	8 days	5 days	·62			
Feb.	11	2	·85	74		
Mar.	13	4	·77	81	77	
Apr.	7	15	·32	55	68	
May	5	8	·38	35	45	
June	6	17	·26	32	34	
July	1	23	·04	15	24	
Aug.	7	23	·23	14	14	
Sept.	1	16	·06	15	14	
Oct.	11	7	·61	33	24	
Nov.	3	11	·21	41	37	
Dec.	3	19	·14	18	29	
1856, Jan.	0	13	·00	7	12	
Feb.	2	7	·22	11	9	
Mar.	0	16	·00	11	11	
Apr.	7	11	·39	20	15	
May	1	20	·05	22	21	
June	7	13	·35	20	21	
July	10	12	·45	40	30	
Aug.	10	14	·42	44	42	
Sept.	12	11	·52	47	45	
Oct.	3	6	·33	43	45	
Nov.	13	9	·59	46	44	
Dec.	7	9	·44	52	49	

An inspection of the numbers in the fifth column will show that the date of the minimum of energy, as exhibited by the spots, may now be assigned with tolerable certainty to the beginning of the month of February 1856, the ratios increasing slowly and perceptibly from that time. The substitution of the numbers in the fifth column for those in the third is simply equivalent to the graphical process of drawing a curve among, but not through, the summits of the ordinates representing the original numbers, a process which may be repeated if the curve still contains too violent inflexions, or may be modified by the introduction

Digitized by Google

of weights. The constitutional peculiarities still remain, but in a milder form.

The system of observation and reduction described in a previous number of the *Monthly Notices* has been continued as before; but it is not intended here to offer any remarks on the results, as through the more pressing nature of other work, Mr. Carrington has not yet been able to give any adequate time to the discussion of the positions observed. The year 1856 has been characterised by the rather frequent occurrence of low south spots, the latitudes 27° south and 35° south having each been more than once visited. As a general remark, it may be stated that when an outbreak occurs on a parallel not previously affected for several months, it is mostly found that two or three other outbreaks succeed at moderate intervals of time, not, however, at the corresponding longitudes, when the rotation of the surface is allowed for; and herein, it is believed by Mr. Carrington, that there lies a something for investigation. This and some other points noticed will, however, be inquired into with better opportunities when more raw material has been accumulated, and when we have arrived at a period of more activity than the present.

Extract of a Letter from Professor Hansen, on an Ancient Eclipse.

(*Communicated by the Astronomer Royal.*)

"I have calculated an ancient eclipse, namely, that of Ennius, of which Cicero gives an account in his work, *De Republicâ*, discovered within the last few years; whence it may be reckoned as one of the most certain and well-established eclipses of antiquity. Ennius says, according to Cicero, 'Nonis Junii soli luna obstitit et nox.' Now, in Cicero's time, the Nones of June fell on the 5th; but, in the time of Ennius, on account of the lunar years and the intercalary month of the Romans, they fell between June 5 and July 4. On this account the following data, which have been investigated for this eclipse, may be considered acceptable:—

399, June 21.					
Greenwich Mean Time.	Moon's Longitude.	Moon's Latitude.	Equatoreal Hor. Par^{x}.	R. A.	Decl.
h m	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″
3 36	82 39 47·4	+0 31 41·1	60 24·65	81 57 37·3	+24 4 13·3
4 48	83 24 0·0	35 45·1		82 45 45·2	10 39·0
6 0	84 8 10·7	39 48·5	22·10	83 33 55·5	16 49·4
7 12	84 52 19·6	43 51·4		84 22 8·5	22 44·3
8 24	85 36 26·6	+0 47 53·7	60 19·35	85 10 23·8	+24 28 23·4

Digitized by Google

G.M.T.	Sun's Longitude.		Log. Rad. Vector.	Sun's R.A.	Sun's Decl.
h m	° ′ ″			° ′ ″	° ′ ″
3 36	83 40 1·7			83 5 12·0	+23 35 44·2
6 0	83 45 45·4		0·00708	11 26·5	36 0·9
8 24	83 51 29·1			83 17 41·3	+23 36 17·0
Obliquity = 23° 44′ 57″·8					

"These places give the following points of the curve of the central eclipse: —

Longitude, East of Greenwich.	Latitude.
° ′	° ′
8 41	44 4
9 39	43 36
10 38	43 8
11 38	42 40
12 37	42 12

"The central eclipse passes, therefore, very nearly over Rome. I have now obtained for Rome: —

	Mean Time at Rome.
	h m
Beginning of the eclipse generally	6 40
Beginning of the total obscuration	7 30
End of the total obscuration	7 33
End of the eclipse generally	8 20

"On this day the sun set at Rome at $7^h\ 36^m$ Roman Mean Time; the total eclipse was, therefore, quite visible at Rome, and the sun set immediately after the completion of it. By this means does the otherwise unintelligible passage of Ennius, 'Soli luna obstitit et nox,' become quite clear; the poet has simply omitted the word 'simul.'

"Professor Zech has previously found an eclipse at the setting of the sun at Rome; but he obtains only a partial eclipse, and its maximum takes place after the sun has set. His longitude of the moon is 8′ 51″ too small, and his latitude is too great by 1′ 46″."

Abstract of a Report on the Determination of the Latitude at Karachi. By Lieut. Tennant, of the Bengal Engineers, First Assistant G. T. Survey of India.

The operation took place in March and April 1855. The paragraphs in inverted commas are from the author's MSS.

"It having been considered desirable that the latitude should be well observed in the neighbourhood of Kărāchi, both as an initial element for the Great Indus Series, which will form

Digitized by Google

the western limit of the G. Trig. Survey operations, and as verificatory of the results of the Great Longitudinal Series, I was instructed by the Surveyor-General during the recess of 1854 to build an observatory in the neighbourhood of the Karachi Base, where this datum might be astronomically determined.

"I finally fixed on Bath Island as the site of the Observatory. The so-called island is an isolated hill situated about half-way between Karachi cantonment church and the Sanatarium of Clifton. It is nearly surrounded by the sea at each high-water, and at the highest spring-tides is completely so. The road from Karachi to Clifton passes to the east at some distance, and there were no buildings of any description on the island.

"In order to secure so valuable a locality, I procured from the commissioner in Sind a grant of the whole island beyond cantonment limits; and it will be a good site for a permanent observatory, should one be established in this part of India. The surface of the island is a loosely conglomerated gravel; but at about 3·5 feet below it, a layer of firmer materials is found, on which the walls, and collimator-, and clock-pillars, are supported; and about 4·5 feet again below this another very firmly consolidated stratum formed the support for the pillars of the instruments." . . .

Drawings, in full detail, accompany the paper, showing the construction of the walls and roof, and provision for ventilation.

"The mark to which each instrument was adjusted is a fine drill-hole in a brass plug, which was fixed in the pillar on the level of the floor.

"The position of the geodesical station is as follows, from the connexion with the Great Longitudinal Series:—

Latitude (from Kalianpur)	24	49	50·2 N.
Longitude (corrected to Taylor's last result for Madras)	67	1	0·7 E.
Height above sea-level of mark	38·10 feet.		

"The last element was determined in the harbour, and the level brought up trigonometrically."

The instruments used were the "Troughton" astronomical circle, described in Col. Everest's account, the Troughton and Simms' 34-inch theodolite, modified in some of its parts, a clock by Jones, and a collimating apparatus extemporised for the occasion.

In selecting the stars for observation, the Surveyor-General had decided that they should be about thirty in number, and should extend over 30° of N.P.D., situated half on each side of the zenith; and that the zenith distances to the north were to be equal to those to the south, as nearly as possible, to eliminate any error in the refractions applied.

The mode of observation was very generally similar to that described in Col. Everest's work. The number of stars ultimately selected was thirty-three, recently determined positions of the

Digitized by Google

whole of which were received from Madras, and of eighteen of which from Greenwich. Lieut. Tennant finds a small outstanding discordance in his two results, when the two authorities for the stars are separately used, which for the present he leaves undecided, giving the preference temporarily to the results from the Madras stars, for reasons stated in the MSS.

The latitude of the Karachi geodesical station thus found (from 807 observations) was—

	°	′	″
By Madras positions of stars	24	49	49·3
Greenwich			50·0

The azimuth of the referring mark was found to be,

	°	′	″
By E. and W. elongations of *Polaris*	179	59	57·4
Same as brought up from Kalianpur			57·7

The intermediate results of the calculations are given in tables at much length.

An Examination of the Figure of the Indian Meridian as deduced by the Venerable Archdeacon Pratt from the two Northern Indian Arcs; with a Proposition for testing that form by Astronomical Observation. By Lieut. J. F. Tennant, Bengal Engineers, F.R.A.S.

1. On my arrival in May last at the Surveyor-General's Office, I met with Mr. Pratt's paper on Himalayan Attraction in the *Philosophical Transactions*, and it occurred to me that the arc of longitude from Kalianpur to Karachi completed in 1853 would furnish a means of verifying its results.

2. When, however, I applied the data given by Mr. Pratt to it and the southern meridianal arc, I became convinced that some error had been committed in the solution of the equations, and I therefore examined this with the following result.

The mean value of $d\,e$ was

$$-0{\cdot}00097840;$$

whence we get

$$e = 0{\cdot}00234605,$$

which coincides to the last figure with the value given in the paper referred to.

On adding, however, the three equations, and substituting this value of e, I found

$$\alpha = -0{\cdot}0019209$$

which differs entirely from the value given for this quantity.

3. Using these values of $d\,e$ and α, I find the following

Digitized by Google

elements for this ellipse, and these being the true results of his paper, I shall use as Mr. Pratt's value, distinguishing them and all deductions from his hypothesis by subscribing the letter P to the algebraical representative of the quantity, and calling this hypothesis P.

$$a_P = 20882740{\cdot}94 \text{ feet.}$$
$$b_P = 20833863{\cdot}65$$
$$e_P = 0{\cdot}00234605$$

4. Similarly I shall call the dimensions given by Colonel Everest in his work of 1830 (and which are still in use), hypothesis E, and subscribe that letter in the same way to its results.

$$* \; a_E = 20922931{\cdot}80 \text{ feet.}$$
$$b_E = 20853374{\cdot}58$$
$$e_E = 0{\cdot}003324449$$

5. I first compared these values with Col. Lambton's arc Damergida to Punæ by means of the formula given in Mr. Airy's treatise "On the Figure of the Earth," and also that in Mr. Pratt's paper.

By the former the length

$$l = b\left\{1 + \frac{e}{2} - \frac{3}{2}e \cdot \cos(\lambda' + \lambda'') \cdot \frac{\sin(\lambda' - \lambda'')}{\lambda' - \lambda''}\right\}(\lambda' - \lambda'') \sin 1''$$

and by the latter

$$l = a\left\{1 - \frac{e}{2} - \frac{3}{2}e \cdot \cos(\lambda' + \lambda'') \frac{\sin(\lambda' - \lambda'')}{\lambda' - \lambda''}\right\}(\lambda' - \lambda'') \sin 1''$$

Now the observed Latitude of Damergida is $18^\circ\ 3'\ 16{\cdot}''075$ for Hyp. E.
And the attraction on hypothesis P ..... + 6·909

∴ The latitude for hypothesis P is ..... 18 3 22·984

Also the observed latitude at Punæ is $8^\circ\ 9'\ 32{\cdot}''509$, which I shall assume without change for both figures. We have then for hypothesis P,

$\lambda'_P + \lambda''_P = 26^\circ\ 12'\ 55{\cdot}''493$ $\qquad$ $\lambda'_P - \lambda''_P = 9^\circ\ 53'\ 50{\cdot}''475$

Whence the length is on hypothesis P, by Mr. Airy's formula 3591803 feet.
,, ,, ,, Mr. Pratt's 3591787 ,,

And, again, for hypothesis E:

$\lambda'_E + \lambda''_E = 26^\circ\ 12'\ 48{\cdot}''584$ $\qquad$ $\lambda'_E - \lambda''_E = 9^\circ\ 53'\ 43{\cdot}''566$

Whence the length is on hypothesis E, by Mr. Airy's formula 3591533 feet.
,, ,, ,, Mr. Pratt's 3591501 ,,

* These lie between the values given by Messrs. Airy and Bessel.

Digitized by Google

6. The true length of this arc being 3591779 feet, it would seem that P gives a closer approximation to it. E, however, is nearest to the unaltered observed data; and, the attracting mass lying to the north, it is not in a southerly direction that hypothesis P would fail, if the attractions are erroneous, till both ends of the arc are beyond the limits of sensible attraction. I have only placed these results here to show that the consideration of this arc has not been neglected, as I do not think it can have any weight against that which follows.

7. In the year 1853 a great arc of longitude was completed, extending from Kalianpur to Karachi in Sind, with the following position of its ends:—

	Latitudes.		Geodetically computed from Madras as an origin.
Kalianpur	24° 7′ 11″·262 observed.	77° 41′ 44″·75	
Karachi..	24 49 50·155 Geod. comput.	67 4 2·47	

The computations, according to the custom of the department, being made on the figure E, commencing with the place of Kalianpur.

On hypothesis E, therefore, the mean latitude of this arc is—

$$\lambda_E = 24^\circ\ 28'\ 31''$$

and its amplitude

$$\Delta L_E = 10^\circ\ 37'\ 42''{\cdot}28$$

8. On hypothesis P, however, the latitude of Kalianpur should be increased by 11″·9, that being the supposed attraction; and as the difference of the latitudes of the extremities will not be materially affected, we shall have

$$\lambda_P = 24^\circ\ 28'\ 43''.$$

9. The value of the length of an arc of longitude is given by Mr. Airy as $= b\{1 + e + e \sin^2\lambda\}\,\Delta L \sin 1''$, and if we assume the length given in both arcs we shall have

$$\Delta L_P = \Delta L_E \cdot \frac{b_E(1 + e_E + e_E \sin^2\lambda_E)}{b_P(1 + e_P + e_P \sin^2\lambda_P)}$$

whence I obtain

$$\Delta L_P = 10^\circ\ 39'\ 2''{\cdot}19 = \Delta L_E + 0^\circ\ 1'\ 19''{\cdot}81.$$

9. In order, however, to compare the longitude of Karachi with an observed value, we must consider that the amplitude from Madras to the meridian of Kalianpur was derived from a figure nearly approximating to E, though the method was not rigorous. The correction on this account may be assumed as + 22″·5, to suit the hypothesis P.

10. At Karachi I observed on the 22d of May, 1853, an occultation of β_1 *Scorpii*, which I have computed with Mr. Adams'

Digitized by Google

value of the lunar parallax and semidiameter. The star's place I took from the Greenwich Results for 1852, and the errors of the Moon's place were interpolated for the mean time from a memorandum kindly furnished by Mr. Airy. Hence I deduced the longitude of my station.

	h	m	s	
By the Immersion..	4	28	3·304	East.
Emersion ..	4	28	5·716	
Mean	4	28	4·510	= 67° 1′ 7″·65 East.

And of the same point reducing to Mr. Taylor's last result for Madras, the longitudes are,

	°	′	″
By hypothesis E ..	67	1	37·64
And by hypothesis P ..	66	59	55·33

E having very decidedly the advantage.

11. The most certain test, however, I have it in my power to apply, is the agreement of the azimuth at Karachi as observed, and that geodetically brought up by computation from Kalianpur.

If the azimuthal angle of B as seen from A be A, and the reverse angle of A seen at B be B, each measured from the north, and we take $B = \pi - (A + \Delta A)$: then, in accordance with Dalby's theorem,

$$\tan \tfrac{1}{2} \Delta A = \frac{\sin \tfrac{1}{2} (\lambda' + \lambda'')}{\cos \tfrac{1}{2} (\lambda' - \lambda'')} \tan \tfrac{1}{2} \Delta L$$

Computing, then, the two values of Δ A from the data already given, we shall have between Kalianpur and Karachi

	°	′	″
ΔA_E =	4	24	50·14
ΔA_P =	4	25	25·16
Difference			35″·02

which, the computations having been made on hypothesis E, should be the discordance of the azimuths at Karachi, the computed value exceeding the observed one, as the azimuths are measured from south by west; but in a paper on the latitude of Karachi, which I have lately transmitted to the Astronomical Society, I have given the comparison of the observed azimuth at Karachi with that brought up geodetically from Kalianpur, showing that the former is in defect only 0″·312.* No errors of observation, and no possible attraction could account for the enormous amount of

* The azimuth at Kalianpur cannot be greatly in error, as the discordance in latitude at Karachi I have shown in the same paper to be only 0″·882, and this is the direction we should expect from the neighbouring elevated masses. It must, besides, be considered that Mr. Pratt's attraction would, if it existed, cause the observed azimuth at Kalianpur to be in defect, and thus the error (including this source) would be increased at Karachi.

Digitized by Google

35″ in azimuth, and it appears alone sufficient evidence that the hypothesis P is irreconcileable with this arc; unless indeed we were to assume in addition, that the minor axis of the generating ellipse is not the axis of the Earth's revolution, but parallel to it, at such a distance, as to retain the radius of the parallel of latitude.

12. A variation from the general form of the Earth's surface so great as that of hypothesis P is difficult to imagine, for the distance of every point in P from the centre is less than that of the corresponding point in E. The evidence of its existence is so combined with that of deflection of the plumb-line without any real change of form, that it appears impossible to separate entirely these deviations; but the following considerations may, I think, at some future time give a means of deciding on the preferable form.

13. In the first place, the attraction is so enormous, if Mr. Pratt's values hold good, near the mountains, that in longitude it should at Banog Hill Station amount to nearly 20″. If this quantity be called ∂ L, ν the normal to the minor axis of the spheroid, and λ the latitude of the station; we should expect all the observed right ascensions of the Moon to be affected with a parallax of the form $-\alpha$ P cosec Moon's N.P.D., where $\alpha = \frac{\nu}{a} \cos\lambda \tan \partial$ L (∂ L being positive when it tends to increase the east longitude), and after correcting all transits by a term of this form (which, however, would be very small), we should obtain the apparent longitude or inclination of the apparent plane of the meridian to that of Greenwich.

14. The parallaxes, however, of the Moon in right ascension and north polar distance would give means for determining the deflection of the zenith in longitude, as the hour-angle from the hour-circle passing through the production of the Earth's radius would be necessary for their determination. This deflection could consequently be determined from occultations, though of course any determination where the errors bear so large a proportion in all likelihood to the quantity sought, as in this case, must necessarily be uncertain.

15. In the same way a geocentric latitude might be determined from occultations, and compared with an assumed figure, but with greater accuracy. Thus by the Great Arc Series of Triangles the latitude of Banog Hill Station, as brought up geodetically from

Kalianpur is	..	..	*30° 28′ 36·96
and that of Kaliana is	..	..	*29 30 44·78
whence the amplitude is (hypothesis E)		..	0 57 42·18

and on hypothesis E the geocentric latitude of Banog would be 30° 18′ 37″·48.

* These differ from the values given in Colonel Everest's work published in 1847, being uncorrected for the discrepancy in latitude at Kaliana.

Digitized by Google

But if hypothesis P be true, the amplitude from Kaliana to

Banog would be	0	57	45·22
and Mr. Pratt's corrected latitude of Kaliana is ..	29	31	16·75
whence the latitude of Banog should be ..	30	29	1·97
and the geocentric value would be	30	21	58·87

16. The difference between the geocentric latitudes of this point on these hypotheses is then $0^\circ\ 3'\ 21''\cdot39$, a large quantity, whose effects would be felt in the parallaxes, for in Admiral Smyth's description of the Bedford Observatory the tenth part of this is spoken of as having a decided effect on the results of occultations.

Possibly by this means we might determine the geocentric latitude within three or four seconds.

17. If an estimate of the attraction at Banog could be made, it would evidently be possible with this and the observed latitude to deduce an angle of the vertex, and an approximate compression of the Earth. The uncertainty of the data, however, and proximity of the attracting masses, would render this result very unsafe, and a preferable proceeding appears to be to determine what constants in the figure of the Earth will deduce the geocentric latitude at the Northern Station from the astronomical latitude of Punæ, which in this investigation we may consider beyond the influence of the mountains.

The compression so obtained would give an astronomical latitude of the Northern Station, which, compared with the observed datum, would show a value of local deflection more trustworthy probably than any resulting from assumed magnitudes, positions and densities of the attracting masses, however carefully these estimates might be made.

I purpose, when my duties in the field allow me, to investigate the necessary formulæ for these determinations.

The instruments at the Lucknow Observatory have, by the annexation of the Kingdom of Oude, become the property of the East India Company. Should it be determined to resume their employment, it may be worth while to remove them to a point on the first Himalayan Range. They might then be employed in determining the longitude close to the axial meridian of India (that of the Great Arc), and in endeavouring to make some estimation of the great local attraction. Situated far above the lower strata of the atmosphere, they would be in a position to examine into the question of "solar refraction" as proposed by Professor C. P. Smyth; and with a telescope of adequate power would be in a more favourable position for micrometrical observations than any other permanently established observatory.

S. G.'s Field Office, Sept. 24, 1856.

Digitized by Google

Various Observations. By W. Lassell, Esq.

"1856, July 28th, $11^h\ 40^m$ G.M.T. Turned the large equatoreal upon the planet *Juno*, and examined it with various powers, from 160 to 1018; but it did not bear the high powers well, and nothing like a *disk* could be seen. In colour it is certainly ruddy, but not so much so as a star of similar magnitude more south in the field, which is a good deal like it in character.

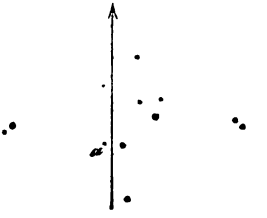
"July 30. Examined *Juno* again with various powers up to 1018, but could get no other image than what a fixed star of similar magnitude would give. It seems scarcely so red to-night, being just on the meridian ($12^h\ 20^m$): I should call it full yellow, or rather orange. There is an exceedingly minute star, nearly south, distant perhaps 20″. *Juno* estimated $8\frac{1}{2}$ magnitude.

"August 3. Scrutinised the planet for some time with 160, 565, and 1018, without detecting anything planetary about the disk; but it is curious that I again see a star, the faintest thing possible (with 24 inches aperture), in the immediate neighbourhood of the planet. Planet estimated to be barely so bright as the $8\frac{1}{2}$ magnitude.

"August 31. Surveyed *Juno* for some time with single lens 479. On comparing the effect of magnifying power on this planet, and on neighbouring stars of similar magnitude, I cannot find that the light fades more on the planet, nor could I by any scrutiny of the planet's appearance distinguish it from a fixed star. The altitude of the planet, however (not 29°), is too low for this telescope and power. I do not detect any minute star near the planet to-night. Sky brilliant, but confused.

"*Comparison of Relative Efficiency of Prism and Plane Speculum*, which are considered to be of equal perfection of workmanship.

"July 30. About $11^h\ 20^m$ observed (not, however, for the first time) a minute star (*a*) north of the most following of the 'debilissimæ,' and about one-fifth of the way towards the northern double.



"I had then the plane speculum in the tube in bright condition; and as the sky was steadily bright and clear, I took out the plane speculum, and put in the prism, also in very good order. Powers 430 and 1018 were used in both instances; and I came to the conclusion that, though this minute point might be called the 'minimum visibile' with either plane, yet it was somewhat more constantly seen with the prism than with the speculum; especially with the lower power, which scarcely sufficed to show it steadily with the speculum. The superiority of vision, however, even with 1018, was not *striking*, though certain, and a very slight deposition of dew on the prism would suffice to neu-

Digitized by Google

tralise the advantage. The speculum never sensibly collects dew. Therefore, it is only on objects of the last degree of faintness, such as the satellites of *Uranus* and *Neptune*, in this telescope, that the general superiority of the prism is apparent.

"November 28. In observing the satellites of *Uranus*, I could not make myself absolutely sure that I saw *Umbriel*, which is generally the faintest of them all, the plane speculum being in the tube. On putting in the prism, the suspected position of *Umbriel* was at once verified. The single drawback to the general use of the prism is its extreme liability to contract dew; and I have in succession resorted to various contrivances to obviate this annoyance. Both the plane specula and the prisms are mounted in boxes, so fitted with steady-pins entering holes in a plate permanently attached to the arm of the small metal, that, by the replacing of a single screw, any one of them can be instantly placed in perfect adjustment in the tube. This arrangement, permitting the examination or change of the prisms almost in a moment, with scarcely an interruption of observations, is highly convenient and even essential. After a trial of various modes of imparting just that increase of temperature to the prism, which shall prevent the deposition of dew, and yet produce no apparent disturbance of the rays of the image by radiation, from inequality of temperature, I finally adopted the following:—

"I made for the prism a triangular tin box, lined internally with wash-leather, only just large enough to contain it. When about to prepare for observation, I put this box in my pocket, close to my person; and by the time I have opened the dome, and pointed the telescope, I take out the prism and place it in the box, with the steady-pins before-mentioned; I then find that, even on a very dewy night, the prism will remain perfectly pure for upwards of two hours. Having a spare prism at the same temperature ready to substitute at the end of that period, only a very few moments are lost by the change. The larger boxes, which contain the prisms when in adjustment, are lined with thick *felt*, to prevent radiation; and I generally keep them at a temperature a little above that of the atmosphere, when about to be put into the tube, though not sufficiently so to feel warm to the hand. I would caution any one, using a prism, against leaving it in the tube permanently. To secure, I presume, the requisite high refractive power of the flint glass used for this purpose, so much lead enters into its composition, that it is by no means invulnerable by constant exposure to the deposition of dew, changes of temperature, and atmospheric action. Moreover, the glass is really much softer than crown-glass, and requires wiping always with caution, and the softest and purest material. A very soft and pure silk handkerchief, deposited in a tin box and kept for the purpose, I always employ. The prisms supplied by the Optical Institute at Munich require this care, and *deserve* it.

Deep-red Stars. "September 5. About $10^h\ 40^m$, while sweeping about *Cygnus* and admiring, with power 160, the wonderful

Digitized by Google

richness and splendour of the milky way, I discovered what appeared to me the deepest red star I have ever seen, magnitude $9\frac{1}{2}$, R.A. $21^h\ 16^m{\cdot}6$, N.P.D. $48^\circ\ 13'$. Many other stars are in the field with it.

"In R.A. $21^h\ 37^m$ N.P.D. $52^\circ\ 42'$ is another deep-red star rather brighter, 8th magnitude.

Curious triple-double Star. "In R.A. $21^h\ 28^m{\cdot}4$, N.P.D. $58^\circ\ 36'$ is a singular group of three stars, each attended by a small companion. The three principal stars form a right-angled triangle, with one side about one-fifth shorter than the other. Calling the star at the most acute angle a, and the others b and c, a is rather brighter than the 10th magnitude, b and c the 11th magnitude, a^2 the 11th, b^2 and c^2 the 12th magnitude. These magnitudes have been determined on the principle of the 'Photometrical Method of measuring the Magnitudes of Stars,' described by the Rev. W. R. Dawes in the eleventh volume of the *Monthly Notices* of the Royal Astronomical Society—a very able paper, which so far as I know has not yet received the attention it deserves. I have not myself, for want of opportunity, verified it by as many observations as I could wish, but I have come to the same conclusion very nearly, with regard to the aperture of a Newtonian telescope required to show a standard 6th-magnitude star; and *that* once determined, Mr. Dawes's method of ascertaining other magnitudes from that standard is extremely rational and simple. But in desiring to ascertain quickly, and with at least sufficient accuracy, the magnitude of a new star found in sweeping, to which some interest may be attached, a good deal of time is lost in trying on different diaphragms in order to ascertain that aperture which will just steadily make the star visible (to say nothing of the great number and variety of diaphragms required in doing this). I have therefore applied an apparatus to the end of the tube of the finder of my large equatoreal, which I find extremely convenient, and which, for magnitudes less than the finder will suffice to show, may be applied to the larger, or indeed any other telescope. My finder is a Newtonian reflector of 4·30 inches aperture and 42 inches focal length, with a magnifying power of 32 times. The end of the tube will just include a square of 3 inches in the side, inscribed within it. I have, therefore, a cap fitting on the end of the tube, out of which such an aperture is accurately cut. At right angles to a diagonal of this square, and at a distance from each other equal to the length of the diagonal, are two cheeks of a dovetail, between which a rectangular plate of metal slides, so that any part of the square can be shut off, and by a graduation on two sides of the square, the exact area exposed can almost without calculation be immediately ascertained.*

* Mr. Lassell's MSS. contained a diagram of his apparatus, which the Editor has not thought necessary for the elucidation of his description. A paragraph or two has here been omitted. See page 83.

Digitized by Google

"Where the determination of the magnitudes of rather small stars is a point of importance, such an apparatus as this might be applied to the object-glass of a refractor, the sliding plate being moved by a light rack and pinion attached to a Hooke's joint and long handle; thus obviating the extreme trouble and difficulty of getting up to the object-glass of a large telescope to change diaphragms. Magnitudes being often supplemental to the primary observation, any saving of time during a clear sky is of the highest importance; and in this method suggested, nothing more is necessary than to read the division on the graduated side of the square at the time, the resulting magnitude being ascertained afterwards at leisure. If to Mr. Dawes's column of lineal apertures a column of corresponding areas be added, the readings of this variable diaphragm may be compared with it by simple inspection almost without a calculation.

"*Close Satellites of Saturn.*—As observations of the nearest two satellites of this interesting planet are only within the scope of the highest class of telescopes, it may be of some interest to give an epoch or two of them.

"On the 6th of November, 1856, at about $13^h\ 20^m$ G.M.T. *Mimas* was seen as nearly as I can judge at his greatest elongation west, and on the 26th December about $11^h\ 50^m$, I observed him just past his greatest western elongation. The opportunities of seeing this minute and quick-moving body are extremely rare, for I have never seen it, or heard of its having been seen, when much removed from one or other of its elongations; and the short period of its transit over those parts of its orbit must occur when the atmosphere is in a fine state, and when the planet is favourably situated for observation. During the present very wide opening of the ring, this satellite is peculiarly difficult to see, and the more precise observation of an *opposition* or *conjunction*, I believe to be quite impossible in the present state of the telescope.

"*Enceladus* is easily seen in a good state of atmosphere in all positions, but I have not often caught it when optically at its precise conjunction or opposition. Such an epoch, however, occurred on the 1st December, when at $12^h\ 35^m$ G.M.T., *Enceladus* was apparently due south of the centre of the ball.

"*Satellites of Jupiter.*—1856, Oct. 5, $10^h\ 45^m$ G. M. T.—The satellites being well situated for comparison, I examined them with power 430. The second is apparently the smallest, the first and fourth seem equal in magnitude; the third is by much the largest. The intrinsic brightness of the first, second, and third, is nearly equal, but the fourth is decidedly less illuminated—indeed it has quite a dull appearance. All have good disks, but the air is moulding and will scarcely allow me to ascertain whether they are perfectly round. The third and fourth seem oval. The planet is very beautiful, but I despair to make a sketch of it. The cloud-like appearance of the principal northern belt is remarkable. A thin strip, north of this ample zone, is very dusky—about the same colour as the principal southern belt: but the very dark cap

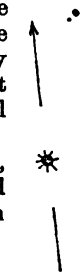
Digitized by Google

which enveloped the northern pole two years ago has quite disappeared. There are certainly chronic changes of great magnitude occasionally occurring on the face of this planet.

"μ^2 *Herculis.*—About two months ago Mr. Dawes drew my attention to this star, merely by the request that I would examine it and tell him 'what was the matter with it.'

"On the 11th November I pointed the telescope upon it with powers 260, 316, and 430. The faint, dull, and generally ill-defined appearance of the star presented a remarkable contrast to the brightness of its neighbour μ itself. On further scrutiny I perceived that μ^2 is double—unequally so, the small companion pointing a little to the north of the line joining μ^2 and μ. The wind was very keen from the north, and vision very bad.

"November 29th, 5^h 0^m G. M. T.—I surveyed the star again under much better circumstances, though it has now got so far into the twilight that it cannot well be seen until it is three hours past the meridian—a condition which the 20-foot telescope never fails to take cognizance of. I saw the duplicity of the star, however, much better than on the former occasion. The contrast of brightness between the minute-double and the principal star is so striking that the possibly planetary nature of the minute-double is forcibly suggested. It might be an earth and moon, dependent upon the principal star as its primary.



"The small double is a livid or faint purple colour, while the single star is brilliant yellow. I obtained measures of μ^2 from μ in position and distance: the mean gave—

Position, 244° 48′. Distance, 30″·62.

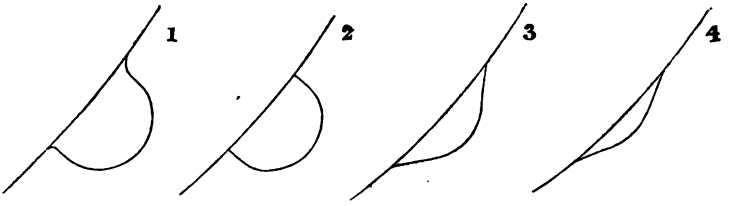
The small double, in Sir William Herschel's nomenclature, I should call very unequal—separated, with 316, nearly a diameter of the small star,—estimated position of the small one from the larger, 55°.

"*Trapezium in the Nebula of Orion.*—December 18.—Vision being very indifferent with the large telescope, I went into the smaller dome and turned the 9-feet equatoreal of nine inches aperture on this object, power 144, with which both the fifth and sixth stars are well seen (or rather *evidently* seen), for the air is much disturbed, though clear. The sixth star appears decidedly the brightest, or the largest, intrinsically, and if in the place of the fifth, would, I think, be more easily seen. Indeed it appears quite as plainly at present. Applied 200—the sixth is now certainly the plainest, and appears to me to be the largest star. But, generally, they are not so easily and instantly seen to-night with 200 as with the lower power. If these stars are unaltered in magnitude, I cannot understand why I should, many years ago, have so often scrutinized the fifth star with this telescope before I detected the sixth.

"*Occultation of Jupiter.*—1857, Jan. 2.—Air exceedingly

Digitized by Google

troubled. Wind high from S.W., wild sky, with clouds most undefined at their edges, and an under-stratum of scud. Immersion of the fourth satellite not observed. The third occupied about $2^{s}.0$ from first contact until it was obscured. *Jupiter* himself was $1^{m}\ 48^{s}.4$ in being occulted. The air was so extremely unsteady that neither *Jupiter* nor the Moon had a well-defined limb. Having directed my attention as carefully as possible to note the phenomena, I am certain that at least an ocular distortion of the planet took place.



"The annexed diagrams convey nearly my impressions of the alterations of form which took place at different periods of the immersion. When three-fourths occulted, the outline of the remaining portion of the planet was obviously that of a hyperbola, and could not be reconciled with the notion of a circular arc. The first and second satellites occupied less time in immersion than the third – as nearly as I could estimate, $1^{s}.5$ and $1^{s}.7$ respectively.

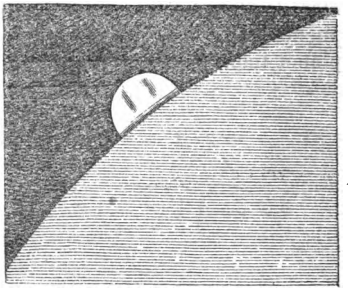
"Shortly after the immersion of *Jupiter* a violent gust of wind occurred, with a very slight shower, after which the sky became more favourable. I, however, missed the emersion of the fourth satellite, and the third was nearly its own diameter clear of the bright edge of the moon when I first saw it. The contrast of its brightness over that of the fourth, when in the neighbourhood of the moon, was most striking.

"The emersion of *Jupiter* was well observed, my eye catching the very first protrusion of its limb. The planet came out without any distortion that I could remark (except that I retain the faintest notion that when the disk was not more than a fifth part emerged, the arc of its circumference seemed to belong to a larger circle than that of the planet). The atmosphere had now become much more steady. The contrast of brightness of *Jupiter* and the moon scarcely seemed to me to be so great as it might be expected to be from the greater distance of *Jupiter* both from the sun and from us. The planet was certainly much paler than the moon, inclining by contrast to a greenish hue; but I doubt if it would appear so much fainter if placed in comparison with a piece of the moon of only the same size. The flood of light emanating from the moon impairs the sensibility of the eye, so that when the eye is directed to the planet, it looks pale; and as a proof, I found that when the moon's edge was kept only just within the field, the contrast

Digitized by Google

appeared to be less. The time occupied by the emersion of *Jupiter* was one beat of the watch less than was occupied by the immersion, viz. $1^m\ 48^s{\cdot}0$.

"But the most remarkable phenomenon of the occultation was that during the emersion, a shadowy line appeared projected on the planet from the edge of the moon, in character, magnitude, and intensity extremely like *Saturn's* obscure ring projected on the ball. The power with which this observation was made, 316, being much less than that with which I usually observe *Saturn*, I suppose that this penumbra was really broader, as it appeared to me to subtend about the same angle. With the exception that on the globe of *Saturn*, the projection of the obscure ring forms a line which is concave towards the opposite limb, whereas this projection from the moon's limb was convex towards *Jupiter's* preceding limb, I should pronounce the two phenomena to be identical in appearance; and whoever has seen the one will form a correct notion of the aspect of the other. I never saw this phenomenon before,—but I never before saw an occultation of *Jupiter* under circumstances so favourable and with so powerful a telescope. I think the planet had advanced one-third of its breadth from behind the moon before I noticed this line, — my attention was immediately and strongly drawn to it, and I watched it until close to the complete emersion of the planet without there being any variation of its appearance beyond a tremor or two from the atmosphere. The phenomenon was unmistakable, and I am satisfied there was no illusion.



"*Satellite of Neptune.*—During the most favourable position of *Neptune* the last autumn, the atmosphere was so generally cloudy here, or otherwise unfavourable, that I have scarcely any observations worth recording; however I send the few I was able to obtain.

		G.M.T.	Position.	Distance.	
		h m	° ′	″	
1856.	Sept. 4	12 19·5	210 46		(*a*)
		12 50·2	....	15·30	
	5	12 29·0	215 24	....	(*b*)
	Oct. 13	11 15·3	37 57	....	(*c*)
		11 2·3	....	17·93	
	19	10 39·5	40 28	....	(*d*)
		10 29·0	....	16·24	
	27	9 14·0	208 5	....	(*e*)

Digitized by Google

REMARKS.

"(*a*) Wind strong from east, sky whitish and stars unsteady, yet the planet is brighter and better defined than I should expect under the circumstances. Measures of position good — those of distance pretty coincident, yet taken with difficulty. Power used, 614; which is the ordinary observing power for this object. Six measures of position taken — extreme difference, 3° 4′. Five measures of distance taken — extreme difference, 1″·45.

"(*b*) The satellite seems about as far off as last night, or rather closer, but it is too faint to measure in distance satisfactorily.

"(*c*) Only three measures of position taken; extreme difference, 1° 34′, and three of distance; extreme difference, 0″·61. Observation considered good.

"(*d*) Satellite seen with great difficulty. Two measures only of position taken, differing 2° 7′; and three of distance; extreme difference, 1″·32.

"(*e*) Only a single measure of position could be got, and that with the greatest difficulty; much haze existing, and the atmosphere very confused. The satellite could barely be seen at intervals, and measures of distance were impossible.

"*Bradstones, Liverpool, 8th Jan.* 1857."

The Occultation of Jupiter on the 2d of January, as observed at Greenwich.

(*Condensed from the Report sent by the Astronomer Royal.*)

Mr. Main observed with the east equatoreal; Mr. Dunkin, with the north equatoreal; Mr. Ellis, with the 46-inch telescope, power 170; Mr. Criswick, with the telescope formerly belonging to the west equatoreal; and Mr. Lynn, with the altazimuth.

Mr. Glaisher's time observations have been omitted, the telescope used being but small. He remarks, "Nothing particular was observed."

Greenwich M. Solar Times by	M.	D.	E.	C.	L.
	h m s	s	s	s	s
Disapp., 4th Sat. first contact	4 44 4·5	...	...	...	...
Disappearance	4 44 5·5	5·7	5·7	14·2	4·2
3d Sat. first contact	4 51 41·1	...	...	...	...
Disappearance	4 51 43·1	42·9	42·9	44·0	43·1
Jupiter's first contact	4 58 33·5	33·8	33·8	32·8	35·0
Last contact	5 0 9·8	9·1	9·3	8·6	7·0
1st Sat. disappearance	5 1 0·6	1·4	1·4	0·4	1·0
2d Sat. first contact	5 2 13·4	...	...	...	...
Disappearance	5 2 14·2	14·2	13·7	13·2	13·1
Reapp., 4th Sat. reappearance	...	...	...	...	...
3d Sat. reappearance	5 49 66·1	46·4	...	...	...
Jupiter's first appear.	5 59 17·1	22·8	17·4	18·9	19·0
Last contact	6 0 52·8	51·6	47·1	48·6	46·8
1st Sat. reappearance	6 1 57·6	64·4	...	...	...
2d Sat. reappearance	6 3 44·3	48·1	42·1	...	47·3

Digitized by Google

Mr. Main adds, that at the disappearance, while the line of contact advanced steadily, it appeared to him to be bent at its extremities more suddenly than corresponded to the curvature of the moon's limb. "Till considerably past the centre, the line of contact ran steadily on, preceded distinctly by a band three or four seconds in breadth considerably brighter than the general surface of the planet. It was in fact so bright as to efface for that space the appearance of the cloud-belts, which I could not trace up to the line of contact." Mr. Main witnessed a reappearance for an instant after its first obliteration of the thin line to which *Jupiter* was finally reduced, and which he felt certain was not a portion of the moon's limb.

Mr. Dunkin remarks, "No distortion of the planet was seen. . . . . When *Jupiter* was about one-half occulted, the moon's limb, which covered the planet, and which up to this time remained perfectly black, became slightly illuminated, remaining so till the final disappearance of *Jupiter*, when it also instantly disappeared. . . . . The times recorded at the reappearance of all the satellites are probably too late by a few seconds; they were seen instantaneously, but there was evidently in each case a space between the satellite and the bright limb. The time of first reappearance of *Jupiter* was also probably late by two or three seconds, but the time of last contact was accurately observed."

Mr. Ellis remarks, "The reappearances of the fourth and third satellites were not looked for, in consequence of the intervening observations of the moon and stars on the meridian. The reappearances observed were all considered rather uncertain as compared with the disappearances. The reappearance of the first satellite was noticed, but the time observed was so uncertain that it was not recorded."

Mr. Criswick remarks, "The time noted for the occultation of the fourth satellite is doubtful, owing to its faintness. The time for the third is very exact. All the satellites appeared to vanish suddenly, with the exception of the third, which seemed to be about half a second disappearing. None of the satellites could be observed on their reappearing, by reason of the brightness of the moon. At the reappearance of the west limb of *Jupiter* it seemed for an instant, before projecting beyond, to shine through the limb of the moon: beyond this I observed nothing unusual during the occultation."

Mr. Lynn remarks, "The disappearances of the satellites were noticed to be gradual, particularly those of the fourth and third; the times noted are those of final disappearance. In the disappearance of *Jupiter* no distortion of the planet was noticed, nor anything peculiar in the line of contact, which was sharp and well defined. The time of first contact was thought to be a little late."

The observations and notes of the above-named gentlemen will, doubtless, be given with all desirable fulness in the Greenwich volume.

Digitized by Google

Occultation of Jupiter, as observed at Liverpool.
By John Hartnup, Esq.

The $8\frac{1}{2}$-inch refractor used. Power 134. Sky changeable. "The dark limb of the moon was well seen. The satellites did not disappear suddenly like the fixed stars. In about three or four seconds after first contact they appeared to have lost fully half their brilliancy; they then faded very rapidly, and disappeared altogether in about three or four tenths of a second. Each of the four satellites presented to my eye this appearance. The disk of *Jupiter* suffered no distortion that I could detect, but at the immersion the planet appeared in contact with the moon for three or four seconds before I saw an impression on the disk of *Jupiter*. The moon during this time did not appear to advance on the planet. I did not observe any projection. As the immersion progressed, the jagged edge of the moon on the face of *Jupiter* was very obvious; and immediately before the final disappearance, the thin thread of light remaining of *Jupiter's* disk was for an instant broken up into three or four *beads*.

"At the emersion, the third satellite first appeared in the middle of a large indentation on the margin of the moon's bright limb. My attention had been previously directed to this crater, which was just then on the edge of the bright limb, and my eye was fixed on it when the satellite emerged. In this large cavity the satellite appeared for several seconds to be quite within the margin of the moon's disk; and if it had been the dark instead of the bright limb, the satellite would probably have appeared projected on the disk of the moon. The contrast between the brightness of the satellites and the moon's limb when they first appeared did not strike me as being great; but when a small portion of the disk of *Jupiter* emerged, the dim copper colour of the planet contrasted strongly with the bright limb of the moon. This contrast diminished gradually as more of the planet came out; and when separated from the moon, it was no longer very remarkable."

The following are the Greenwich mean times of immersion and emersion:—

	Immersion.	Emersion.
	h m s	h m s
4th Sat.	4 47 27·84	.....
3d Sat.	4 54 16·81	5 43 39·55
Jup. 1 L.	5 0 31·97	5 53 18·95
Jup. 2 L.	5 2 20·08	5 55 5·66
1st Sat.	5 2 56·18	5 56 22·45
2d Sat.	5 4 4·99	5 58 6·46

Digitized by Google

Occultation of Jupiter, January 2, 1857, observed at the Armagh Observatory. By Mr. N. M'Neil Edmondson.

(*Communicated by Dr. Robinson.*)

	h	m	s
Immersion of 4th Satellite	4	23	56·62
,, 3d ,, ...	4	29	42·18
Contact of Jupiter noticed at	4	35	0·81
Immersion of Jupiter	4	37	6·46
Immersion of 2d Satellite	4	38	23·25

The telescope was a 15-inch Cassegrain, with a power of 260. No change was noticed in the planet. Mr. Edmondson estimated the time of the 4th satellite's entrance to be $0^s.5$, and that of the 2d to be $0^s.75$. The dark limb was barely visible.

The Occultation of Jupiter, as observed at Oxford. Communicated by the President.

Immersions and Emersions in Oxford Mean Time.

		Mr. Johnson.	Mr. Pogson.	Mr. Quirling.
		h m s	s	s
Immersion,	4th Sat.	4 39 10·3	15·3	
——	3d Sat.	4 46 39·0	37·7	37·0
——	Jup. I. L.	4 53 36·9 (?)	19·3	
——	Jup. II. L.	4 54 58·1	59·2	57·8
——	1st Sat.	4 55 47·3	46·2	
——	2d Sat.	4 56 58·1	57·7	57·3
Emersion,	4th Sat.	5		
——	3d Sat.	5 42	24·7	
——	Jup. I. L.	5 52 3·9	2·3 (?)	
——	Jup. II. L.	5 53 45·6 (?)	32·1	35·2
——	1st Sat.	5 54	42·4	
——	2d Sat.	5 56 34·7	33·1	

Mr. Johnson observed with the heliometer of 7·5 inches aperture, and power 150: Mr. Pogson, with the equatoreal of 7·2 inches aperture, and power 93; Mr. Quirling, with an achromatic by Dollond, of 3·5 inches aperture, and power 38. The sky was frequently overspread with light clouds, and the moon surrounded by a corona, but not at any time of sufficient importance to interfere with the observations.

Mr. Johnson considers it probable that an error of ten or twenty seconds may have been made in noting the time of first contact by the chronometer, though the phenomenon was accurately remarked. The colour of *Jupiter* on emersion was sea-green. Mr. Johnson also felt conscious that the emersion of the second limb was noted too late.

Digitized by Google

Mr. Pogson describes the third satellite as occupying nearly two seconds in fading away. The colour of *Jupiter* was considered dull bluish-white; the belts were always well seen. *Jupiter* was less bright than most part of the moon's surface, but not of so feeble a light as the central part of *Mare Crisium*. The calculated interval of immersion or emersion of the planet at Oxford, was $1^m\ 40^s.8$.

The following observations were made by Mr. Wm. Luff, at his house, which is situated 26″ south and $1^s.3$ east of the Radcliffe Observatory:—

Mean Times at Mr. Luff's house.

Object.	Immersion. h m s	Emersion. h m s
4th Sat.	4 39 12·6	
3d Sat.	4 46 37·8	
Jup. I. L.	.....	5 52 5·4
Jup. II. L.	4 54 57·0	5 53 36·0
2d Sat.	4 56 58·6	

The telescope employed had an aperture of 2·6 inches, and power of about 50. The belts were distinctly seen when only one-third of *Jupiter's* diameter had emerged from behind the moon. Mr. Luff also remarked at the same time the comparative dullness of the planet's light in contrast with that of our own satellite.

Occultation of Jupiter, observed at Ventnor.

By Dr. R. J. Mann.

Telescope by Ross, 3¼ inches aperture: power 120.

"The condition of the atmosphere was eminently favourable for the observation, the performance of the telescope being excellent, and the definition very sharp throughout, so much so that about an hour after the termination of the occultation the dusky ring of *Saturn* was visible with the same instrument, under a magnifying power of 195, although the planet was still at a low altitude.

"At $4^h\ 51^m\ 29^s$ contact had certainly occurred between *Jupiter's* disk and the moon. The planet then seemed a trifle flat at one part of its margin, as if suddenly compressed there; immediately afterwards a *sharp* black line was perceptible, advancing over the planetary disk, and cutting the belts. The lunar surface was quite invisible, and the effect was just that of a flat black ebony ruler, with an even edge, being pushed gradually forward in front of the planet. The uncovered portion of the planetary disk during the progress of the occultation retained precisely its *usual* appearance, *the belts remaining ordinarily distinct quite up to the moon's edge*. The outline of the moon's limb was affected by a slightly tremulous movement, but no irregularity was otherwise observable in it, until immediately before the completion of the occultation; then for a passing instant two or three isolated light points hung in the field of vision; in another instant, but one remained; in yet

Digitized by Google

another instant that was gone. The final disappearance was so distinctly marked, that it could have been fixed easily to the tenth of a second.

"At about $4^h\ 52^m$ the illuminated border of the moon was observed in a state of most exquisitely clear definition. The fourth and third satellites of *Jupiter* were then advanced well away from the moon, but served admirably to indicate the precise point at which the planet was to be looked for. At $5^h\ 52^m\ 22^s$ a minute blotch of very peculiar and unlunar-looking light appeared as if *in front of* the moon's edge, seemingly projected upon the lunar surface. In another second a well-defined segment of the planet's disk was visible, clearly protruding beyond the sharply-cut lunar edge. From this time the difference of the planetary and lunar lights became very remarkable, the hue of the planet being an exceedingly *soft* greenish grey. When the disk of the planet was half exposed the belts presented themselves with far finer definition than they have ever been seen with before in the same telescope, *particularly towards the limb of the planet most remote from the* moon. For more than a minute they were traceable quite up to the edge of the planet's face with a lucidity strikingly unusual. They were also plainly *discernible up to the moon's edge*, but not so obviously as they had been when the dark limb of the moon was lying over the planet previously to the occultation. The surfaces of the moon and the planet were severed by a *half-transparent dusky line*, which had the appearance of being stippled off into the softer hue of the planet's disk. As nothing of this kind presented itself while the moon was passing in front of the planet, it is probable the effect was simply optical, and in some way due to the influence of the superior brilliancy of the lunar light. The effect was, however, very obvious and unmistakable."

Occultation of Jupiter, observed at Haddenham, Bucks, on 2d January, 1857. By the Rev. W. R. Dawes.

"The observations were made with the 8-inch object-glass, by Alvan Clark, mounted equatoreally, and driven by clockwork.

"The state of the air was not very favourable at first; a thin hazy cloud producing diffusion of the moon's light, and rendering the obscure part of the moon quite invisible. A parallel wire micrometer was applied. I intended to observe with power 235; but shortly before the dark edge of the moon reached the fourth satellite, which was near its greatest elongation westward, the thin cloud rendered a lower power preferable, and I exchanged it for 160. Before I could get my eye settled again at the eye-piece, the fourth satellite disappeared.

"The *Third Satellite* disappeared at about $4^h\ 52^m$ G.M.T. The moon's dark edge, which was quite visible upon it, occupied about three seconds in passing over its disk.

Digitized by Google

"*Jupiter's* total disappearance occurred at about $5^h\ 0^m\ 15^s$ G.M.T. Definition pretty good at the time: the outline of the planet, and the belts, were sharply defined, as was also the dark edge of the moon upon the planet's disk. A large mountainous projection was seen on the part of the moon's limb, nearest the north belt. Not the slightest distortion was seen of the general form of the planet; nor were the belts in the least degree obscured by the proximity of the moon's edge. I, however, noticed a very slight *extension of the light along the dark edge*, to a distance of a second or two on each side of the planet's disk, which continued to be visible throughout the occultation. I have often noticed a similar appearance on the edges of a thick wire, when placed across the disk of a bright planet.

"*First Satellite.*—The edge of the moon occupied *a trifle more than two seconds* in passing over this satellite, and was distinctly visible upon its disk. Time not noted.

"*Second Satellite.*—The moon took *not quite two seconds* in occulting this satellite: between four and five beats of the chronometer were counted, which = about $1^s{\cdot}8$. Edge distinctly seen upon it. Time of disappearance not noted.

"*Reappearance of Fourth Satellite*, at the moon's bright edge. Having previously placed a wire of the micrometer, so as to indicate the point of the limb where the satellite would reappear, my eye caught it the instant it projected from the edge, which was at that place very free from inequalities. I counted about four beats of the chronometer (= $1^s{\cdot}6$) before it was quite free from the moon's edge. There was no projection on the edge, nor any unwillingness to separate. The colour of this satellite did not differ much from that of the moon, perhaps a trifle redder; but it was decidedly *fainter*. It came out as a perfectly round little disk, quite free from distortion. Time about $5^h\ 36^m\ 50^s$ G.M.T.

"*Reappearance of Third Satellite*, at about $5^h\ 48^m\ 8^s$ G.M.T. Time occupied in coming out about six or seven beats of the chronometer (= $2^s{\cdot}6 \pm$), from first catching sight of it; my eye being well directed to the place by the micrometer wire. Colour of the satellite a *pale green*. It lost its light from contact with the moon's bright edge to a far greater extent than the fourth satellite did, in proportion to their usual brilliancy. Quite round, and free from any adhesion.

"*Jupiter* was of a *pale green* at its reappearance. Its *figure was perfect;* no distortion, nor diffusion of light where the edge of the moon cut the edges of the planet. A pale *bluish-purple* line, darkest close to the moon's edge, and gradually fading away, was visible on the disk of *Jupiter*. Its breadth was about 5″, as nearly as I could judge. This was evidently *the bluish fringe of the secondary spectrum*,—the object-glass being a little overcorrected. Both the planet and the moon were sharply defined and pretty quiet. Total reappearance at about $5^h\ 59^m\ 15^s$ G.M.T.

"*Reappearance of the First Satellite*, at about $6^h\ 1^m\ 30^s$ G.M.T. Occupied about four or five beats of the chronometer in coming

Digitized by Google

out (= 1ˢ·8 ±) from the first glimpse I observed of it. Not so pale as the third satellite, though obviously smaller, and seemed to suffer less in brightness from proximity to the moon. Quite round.

"*Reappearance of the Second Satellite*, occupied about four beats of the chronometer (= 1ˢ·6) after being first seen. The place was well indicated, as before, by the micrometer wire. The colour of this satellite was like that of the first, but its disk was obviously smaller. It was quite round, and parted from the moon without hesitation.

"The approximate geographical position of my observatory is in lat. 51° 45′ 50″ north, and long. 3ᵐ 44ˢ·0 west."

Note on the Occultation of Jupiter of January 2, 1857.
By W. R. Grove, Esq., V.P.R.S.

"Owing to the great kindness of Mr. Gillett, I was enabled to observe this occultation through his binocular telescope. This instrument is by Ross, the object-glasses 3⅛ inches diameter, focal length 51 inches: portions (about ¼ inch) of the glasses are ground away to enable them to be approximated sufficiently for the distance between the eyes of the observer. The power used was 60, which gave a greater idea of magnitude than double that power in a monocular telescope.

"The dark limb of the moon was faintly visible throughout the time of the occultation. The disappearance of the satellites was not instantaneous as with a fixed star, but (as indeed might have been expected) they gradually faded away. The light of the moon's edge was too feeble for me to ascertain whether they disappeared at the exact edge or not. I should say that they seemed to be a little within it, but I could not positively assert this. *Jupiter* was cut off with perfect sharpness, and I could not detect the slightest distortion. When about one-third was eclipsed the light of the planet appeared brighter along the edge of the moon, and this apparently increased brightness continued until it was about three-fourths eclipsed. Two spots in the neighbourhood of the upper belt (as viewed by inverting telescope) were notably bright, so as to attract attention, and they continued so during the period above mentioned, each looking somewhat like an electric glow coming off the dark edge of the moon. This effect may be optical, and caused by the immediate proximity of darkness to central and more luminous portions of the planet, but it was very marked. I observed no other effect during the period of immersion. I looked for an effect said to have been observed on previous occasions, viz. a faint illumination of the dark edge of the moon upon contact, but could not detect the slightest trace of it. On emersion I could detect no distortion of any sort, nor did I see the dark line which I noticed in the occultation of Nov. 8, 1856. The difference of light and colour between the planet and the moon was the same as then observed.

Digitized by Google

"After emersion there was a decided stereoscopic effect, seen both by Mr. Gillett (who, up to this time had left the telescope entirely to me,) and myself, *Jupiter* in the binocular appearing as at a distance behind the moon. Mr. Gillett tells me that with terrestrial objects the effect of the binocular, if inverting eye-glasses are used, is in many instances pseudoscopic, the more distant objects appearing nearer than the more proximate, which is the effect that theory would indicate.

"The satellite, last in order on emersion, seemed to cling for a second or so to the moon's edge, probably an effect due to irradiation. I did not observe this with the three others, but I did not catch the moments of emersion so well with them. I was greatly struck by the beautiful impression conveyed to the mind by the binocular telescope, and judging from what I had seen with a monocular telescope of my own, of 4·3 inches aperture, and therefore not far differing in area from the compound area of the two object-glasses in the binocular, the latter was decidedly superior, and the ease and, if I may be allowed the expression, the *naturalness* of the vision, was very remarkable."

Note on the Occultation of Jupiter on the 2d January, 1857. By Mr. John Watson, Washington Chemical Works, Durham.

"The evening of the 2d instant being remarkably clear, I resolved to watch the appearance of *Jupiter* in a *star-gazing fashion* only during the occultation, leaving the time-observations to other and better-equipped observatories. To secure the utmost degree of stability, I placed the telescope, a 9-ft. Newtonian of 8-inches aperture, power 100, with its lower end on the ground, supporting the upper end of the tube with a Smeaton's stand.

"The satellites disappeared at the slightly illuminated edge of the moon, without anything unusual being noticed. From the moment of first contact *Jupiter* disappeared smoothly and gradually, and without the least perceptible distortion. The couple of minutes which elapsed between first contact and total disappearance afforded abundance of time to notice the well-defined, curved outline of the moon as projected on the disk of *Jupiter*, and also to observe that the belts of the planet could easily be traced *unaltered* up to the moon's dark limb.

"The two preceding satellites served admirably as *pointers* to indicate the place of emersion at the bright side of the moon. As *Jupiter* emerged from behind the moon, the belts were again noticed *unaltered;* nor was the least distortion observed on the edges of either the moon or planet. No dark line of separation could be seen; but the greenish tint, noticed by Mr. De la Rue in November, was very perceptible on the face of *Jupiter*.

"I should not have considered it necessary to lay before the Society a paper containing so many negative results had not some other published observations been so widely different."

Digitized by Google

Mr. Slatter, of Rose Hill, Oxford, writes:—"The time and sky on the 2d were so favourable that I dare say you will be inundated with notices. I venture to add mine." The planet emerged "with no distortion of image. The moon's limb was very wavering; the planet's perfectly defined and steady: its colour had a slight inclination to green; I conclude by contrast."

"The first satellite emerged also in all respects as it had entered; but the second satellite remained hanging to the moon's limb for four seconds: during the first second, I thought it must be an inequality on the moon's limb; but its greater paleness showed it to be the satellite: when it let go the moon's limb, it started away spasmodically a considerable space.

"I have hitherto been rather sceptical about such appearances, attributing them to the want of power in the instrument, or the fatigued vision of the observer; but what I saw I feel sure was the effect of our own atmosphere, and no lunar appendage.

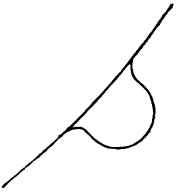
"It is worthy of remark that the flickerings were entirely interrupted at that part of the Moon's limb, at which the planet was emerging. I remember noticing the same thing very particularly in the case of the sun's limb on the occasion of the transit of *Mercury* in 1848.

"I make the following extract from my book, Nov. 9, of that year: 'Very difficult to say when *Mercury* was fully in, as the sun's limb was very wavy: certainly no black thread formed. The power used was 117, the lowest of the micrometer being too high for the day. Air loaded with vapour. It is to be noted that the first appulse was easily visible, because it *stopped* the apparent waves on the sun's limb.'"

Occultation of Jupiter. By W. Simms, Esq.

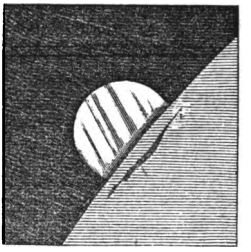
"The occultation of the planet *Jupiter* by the moon on the 2d inst. was seen by me at Carshalton: the immersion with an achromatic object-glass of 15 inches, and the emersion with one of 13 inches aperture, and a power of 200 in both cases.

"The moon's limb advanced steadily over the planet till the latter was about half occulted, when I observed that at the extremities of the line of contact the planet appeared as represented in the accompanying figure, and this appearance continued till only a very small part of the planet remained visible. It is true that there was, at the time, much unsteadiness of atmosphere, but I watched the phenomenon very attentively, and believe I was not mistaken.



Digitized by Google

"The only remarkable appearance noticed by me during the emersion was the very positive line by which the moon's limb was marked upon the planet; dark as the mark of a black-lead pencil close to the limb, and gradually softened off as the distance increased.



"The occultation was observed in London by Messrs. James Simms and W. Simms, jun., by the former with a telescope of $2\frac{1}{4}$ inches, and by the latter with one of $5\frac{1}{2}$ inches aperture. The appearance noticed by me during the immersion was not seen by either of them, but the line defining the moon's limb upon the body of the planet was distinctly seen by both."

In addition to the foregoing accounts, which are for the most part given nearly as received from their respective authors, are many others from which extracts only can be taken.

Dr. Lee observed with his assistant, Mr. Horton, and forwarded letters and sketches from Dr. Brereton of Bedford, and Dr. Turnbull of Aylesbury.

Mr. T. Dell, of Aylesbury, observing with a power of 100, noticed no distortion till five or six seconds before immersion, when the limb became much elongated. The same thing was observed for about the same space of time at the emersion of the first limb.

The Rev. C. Lowndes, of Hartwell, observing with a power of 240, remarked that the limb of *Jupiter* became elongated a few seconds before immersion, and that the light appeared to increase and redden at the side nearest the moon.

Mr. John Peto, writing from Brighton, where he observed with a 5-feet refractor by Tulley, and power 120, says, "The planet emerged steadily till it had nearly left the moon, when for a few seconds it appeared projected on the moon's disk; a dark line, as if of shadow, defining the edge. The pale greenish light of *Jupiter* contrasted strongly with the golden colour of the moon."

Mr. R. Hodgson observed with an 8-feet equatoreal of 6 inches aperture, and power 160. "Not the slightest change of form or colour was noticed." At emersion the light of *Jupiter* appeared pale, and slightly tinged with blue as compared with the moon. Mr. Hodgson writes at the same time, that with the same telescope, and power 140, he witnessed a projection of the first satellite on the disk of *Jupiter* on the 3d of January, with a clear space around it for nearly a minute.

The Rev. T. W. Webb observed with a $5\frac{1}{2}$-feet achromatic, and power 144, from Hardwick, near Hay, South Wales. He

Digitized by Google

writes, "The planet exhibited no distortion, or other unusual appearance, but it left behind it a diffused glimmering of small extent upon the limb, which might probably be due to the want of more perfect definition." Mr. Webb speaks also of the contrast of the paler light of *Jupiter* with that of the moon, and adds, "From which, in all probability, arose the appearance, which seemed to exist, of a narrow darkish border attached to the lunar limb."

Mr. W. Huggins, of Tulse Hill, Norwood, sent his observed times of immersion and emersion. He saw no distortion or projection at either.

Mr. Hippisley, in a letter to Mr. De la Rue, mentions having seen a distortion of form which he describes thus:—"One thing struck me very much, which I did not at all expect, and am pretty sure was not illusive, which was the flattening of *Jupiter's* limb next the moon at the moment at which the line of darkness between the lunar and jovian limbs appeared (*i. e.* at emersion), so that to my eye the equatoreal diameter of the planet did not for a second or two seem more than the polar."

Mr. F. Brodie, of Eastbourne, observed with his $7\frac{1}{2}$-inch glass, and power 106. He writes, "I did not notice any distortion of the disk of the planet either at its disappearance or reappearance. I was, however, very much struck with the disappearance of the fourth and third satellites. The moon's disk gradually advanced over the disk of the satellite, and when the satellite's disk had quite vanished, there remained a small semi-halo of light for the space of one-third to half a second around the point of its disappearance, forcibly reminding me of a *sunset in miniature*." The times of occultation were sent.

Mr. Perigal sent his observations of immersion and emersion taken at Lewisham, where he used a small telescope by Dollond. He saw no distortion or projection.

Mr. T. W. Burr, of Highbury, writes, "At the moment of contact the dark limb of the moon became suddenly illuminated to the extent of about three diameters of the planet both above and below it. The appearance was that of a thin line of silvery light, shading rapidly off to the inside of the circle. It was almost momentary in duration, certainly not exceeding two seconds. I had previously satisfied myself that the whole disk of the moon was not visible by the ashy light usually seen when it is young." Mr. Burr also sent local sidereal times of the occultation.

Mr. J. W. Jeans, of Grantham, made similar observations, but under unfavourable circumstances. He forwarded his observed times, and sent with them an account of the previous occultation on the 8th of Nov. 1856, which laboured, however, under the same disadvantages.

Mr. Matthew Jee, of Edge Hill, Liverpool, sent a short account through Mr. Hartnup.

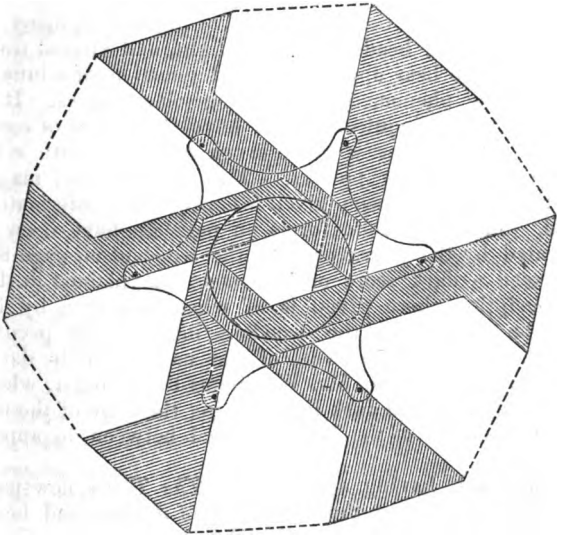
Lord Wrottesley sent a short account of the observations taken at his observatory at Wrottesley with the 11-feet equatoreal, and power 140. No distortion was noticed. "It should, however, be

Digitized by Google

observed that for some seconds after the first contact a rosy purplish light appeared on the moon's limb where the planet was disappearing."

Mr. Worthington, of Crumpsall Hall, Manchester, observed with a refractor of 5 inches aperture, power 125, in company with his friend Mr. Baxendell, to whom he gave up his Newtonian of 13 inches aperture, focal length 9 feet, power 108. "Mr. Baxendell observed that the limb of the planet at the point of contact with the dark limb of the moon suddenly presented a reddish appearance. . . . . Neither of us perceived any distortion of the form of the planet." The times observed were sent. The position of Mr. Worthington's observatory was also stated to be—latitude 53° 30′ 49″·2, longitude 8^m 55^s west.

The Editor of the present *Notice* has been induced, by the perusal of Mr. Lassell's communication, in which is proposed a construction of diaphragm for measuring the area of object-glass exposed during photometric measurements, to send the following one, which has been applied to the equatoreal at Redhill for more than two years past. The inner circle in the figure represents the



full size of the object-glass, on to the end of which is fitted the piece with the re-entering curves, containing the centres of motion of six thin plates of brass, formed somewhat like knife-blades.

Digitized by Google

The construction is so simple as to require little explanation. The one idea in it is the use of parallel motion, whereby, by the introduction of the connecting pieces, represented by the dotted lines, the six blades are constrained to move simultaneously through equal angles, their inner edges then forming a hexagonal diaphragm variable in dimensions at the pleasure of the observer, who is supposed to be furnished with a light rod led down the tube of the telescope, carrying at its upper end a small pinion, working in a piece of rack-work attached to any one of the blades. An indicating-plate at the lower end serves to show the aperture at any moment. The above plan has been kept back hitherto from an unwillingness to communicate schemes unaccompanied by results of observation; but as copies have been given to various friends, and the present appears a natural occasion to introduce it to these pages, it is herewith given as a note to Mr. Lassell's paper. It is well known that Steinheil attains a similar result by the use of a movable circular stop within the telescope tube. It is not, however, intended to discuss the relative merits of the different constructions.—[R. C. C.]

A considerable portion of the present *Notice* has been devoted to accounts of the occultation of *Jupiter*, as many appearances of distortion, beads, scattered light, and altered tints were witnessed, which bear upon the vexed question of a lunar atmosphere and the phenomena seen during solar eclipses. It seemed desirable that the inquirer should have the power of comparing the results of observer with observer, refractors with reflectors, high powers with low powers. The aperture and magnifying power has, therefore, been given wherever the information was supplied. The hyperbolic forms on page 69 have been a little exaggerated by the engraver. In the woodcut on page 81 there will be seen a dark score on the moon unexplained in the text. The description there given is of what was seen by Mr. W. Simms the elder; but the woodcut includes the peculiarities seen by the two other observers of that name, and the dark mark in question was seen by Mr. W. Simms the younger, who states that, together with the dark line defining the edge of the moon, it caused the portion of the body included between to appear unusually bright.

A paragraph having appeared in *The Times* newspaper, in which it was stated that the whole disk of *Jupiter* had been seen projected on the moon, by a 'Dr. Forster on the Continent,' the Editor wrote to Dr. Förster of the Berlin Observatory, and is authorised to state that no such appearance was seen by *him*, the weather having been such as to prevent the occultation being observed at all at Berlin.

Digitized by Google

The 4th volume of the *Markree Catalogue* has just appeared, containing the approximate positions of an additional 14951 stars; making a present total of 60066. A supplementary volume will still be required for the publication of a few unfinished zones.

Mr. Hind has just circulated a new *Sweeping-Ephemeris of the Great Comet of* 1556, in which geocentric positions, computed from new elements, are given for every tenth day of the year.

We learn by No. 1064 of the *Astronomische Nachrichten*, that Dr. Argelander has just published the first four charts of his proposed *Atlas of the Northern Heavens for the beginning of the Year* 1855. We may have occasion to refer again to this projected work in a future number.

To be sold, the property of a Fellow of the Society, a small altitude and azimuth instrument, by W. and S. Jones of Holborn, London. The circles are six inches in diameter. May be seen at the chambers of T. W. Burr, Esq., 12 Paternoster Row. Price *9l.*

ERRATA.

Vol. xii., p. 34, line 8 from the bottom, *for* $2^h\ 1^m$, *read* 2^h P.M.

— xiii., — 218, line 31, *for* 'combination,' *read* 'continuation.'

— xiv., — 158, line 2, *for* 'on,' *read* 'or.'

— xv., — 9, read thus,—
For the horizontal semidiameter = 4″·750484
For the vertical semidiameter = 4 ·750554

— xv., — 14, last line, *for* 'greater,' *read* 'less.'

— xv., — 140, line 3 in the note, *read* 'coincides *best* practically.'

— xv., — 144, line 18, *for* 'official fiction,' *read* 'friction.'

— xvi., — 63, line 11. Substitute the words, 'Very few *accessory dots* were seen' for the words, 'There were very few penumbræ without a nucleus.' The word in the German is *Nebenpunkten*, denoting the little changeable dots so frequently sprinkled around the main spot.

— xvi., — 185, line 12, *for* 'zinc-ball,' *read* 'time-ball.'

Digitized by Google

CONTENTS.

Page

Fellows elected 51

Observations of small Planets made at the Royal Observatory ... ... ib.

Occultation of *Jupiter* on Oct. 12, 1856, observed at Madras, by Capt. Jacob 52

Occultation of the *Pleiades*, observed by Capt. Jacob 53

Occultation of Stars observed by Mr. Burr ... ... ib.

Notice of his Solar-spot Observations, by Mr. Carrington ... ... ib.

Professor Hansen on an Ancient Eclipse 55

Abstract of a Report on the Determination of the Latitude at Karachi by Lieut. Tennant 56

An Examination of the Figure of the Indian Meridian as deduced by Archdeacon Pratt from the two Northern Indian Arcs, by Lieut. Tennant... 58

Note on the Lucknow Observatory 63

Mr. Lassell. Scrutiny of the Planet *Juno* 64

— Comparison of Prism and Plane Speculum ... ... ib.

— On Preventing the Deposition of Dew 65

— Curious Triple-double Star 66

— Proposed Diaphragm for Rough Measurement of Relative Magnitude ... ... ib.

— Close Satellites of *Saturn* 67

— μ^2 *Herculis* a double star 68

— Trapezium in *Orion* ... ... ib.

— Occultation of *Jupiter*, Jan. 2 69

— Satellite of *Neptune* 70

Occultation of *Jupiter* on the 2d of January, observed by Messrs.

Main,	Johnson,	Watson,	Turnbull,	Brodie,
Glaisher,	Pogson,	Slatter,	Dell,	Perigal,
Dunkin,	Quirling,	Simms,	Lowndes,	Burr,
Ellis,	Luff,	J. Simms,	Peto,	Jeans,
Criswick,	Mann,	W. Simms, Jun.	Hodgson,	Jee,
Lynn,	Dawes,	Lee,	Webb,	Wrottesley,
Hartnup,	Grove,	Horton,	Huggins,	Worthington,
Edmondson,	Gillett,	Brereton,	Hippisley,	Baxendell,

71–83

Mr. Carrington. Plan of a variable hexagonal diaphragm 83

Miscellaneous 85

London:—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, February 5, 1857.

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *February* 13, 1857. No. 4.

THE Annual General Meeting of the Society, MANUEL J. JOHNSON, Esq., President, in the Chair.

William Curtis Otter, Esq., 18 Grosvenor Park (North), Camberwell; and
William Walter Spencer Stanhope, Esq., 51 Harley Street,
were balloted for and duly elected Fellows of the Society.

Report of the Council to the Thirty-seventh Annual General Meeting of the Society.

The Council proceed to lay before the Fellows their Report for the past year. There have been years in which there has been more of striking interest to detail; but, nevertheless, the science of astronomy, though perhaps the oldest of the sisterhood, shows every sign of continued vitality.

The Report of the Auditors, subjoined, will show the state of the finances:—

RECEIPTS.

	£	s.	d.
Balance of last year's account	578	3	7
By dividend on £1650 Consols	23	2	0
By ditto on £2878 17*s.* 5*d.* new 3 per Cents	40	6	1
By ditto on £1650 Consols	23	2	0
By ditto on £2878 17*s.* 5*d.* new 3 per Cents	40	6	1
Cash per Lawson's executors	200	0	0
Dividend on £1650 Consols	23	2	0
On account of arrears of contributions	70	18	0
102 contributions (1856–57)	214	4	0
5 ditto (1857–58)	10	10	0
Carried forward	£1223	13	9

Digitized by Google

	£	s.	d.
Brought forward	1223	13	9
Compositions	94	10	0
15 admission-fees	31	10	0
14 first year's contributions	24	3	0
Sale of Publications	79	3	6
	£1453	0	3

EXPENDITURE.

	£	s.	d.
Cash paid George Barclay, printer	165	5	8
Ditto J. W. Rumfitt, bookbinder	10	0	0
Ditto Mr. R. Grant	20	0	0
Ditto J. Deville, gas-fittings	29	18	6
Ditto Mr. R. Grant	10	0	0
Ditto J. Binnington, carpenter	27	0	6
Ditto G. Barclay, printer	142	5	9
Ditto J. W. Rumfitt, bookbinder	18	19	6
Taxes { 1 year's land tax 5 10 0; half-year's property tax 3 6 8	8	16	8
J. Williams' salary, 1 year	100	0	0
Ditto commission on collecting £430 8s. 6d.	21	10	6
Charges on books, and carriage of parcels	2	5	3
Postage of letters and Monthly Notices	28	2	5
Porter's and charwoman's work	25	3	10
Tea, sugar, biscuits, &c. for evening meetings	15	13	0
Coals, candles, &c.	12	10	6
Waiters attending meetings	4	8	0
Sundry disbursements by the Treasurer	36	18	10
Expenditure of Turnor Fund	9	3	6
Banker's commission on collecting country cheque	0	1	0
Balance in the hands of the Treasurer	764	16	10
	£1453	0	3

Assets and present property of the Society on Feb. 8, 1857:—

		£	s.	d.
Balance in the Treasurer's hands, including £36 0s. 11d. balance of Turnor Fund		764	16	10
Due for arrears on which various sums have been paid by 4 Fellows		41	19	0
3 contributions of 5 years' standing	31 10 0			
4 ——— of 4 ditto	33 12 0			
4 ——— of 3 ditto	25 4 0			
19 ——— of 2 ditto	79 16 0			
26 ——— of 1 ditto	54 12 0			
		224	14	0
Due for publications of the Society		1	8	6

£1650 3 per Cent Consols.
£2878 17s. 5d. new 3 per Cent.
Unsold publications of the Society.
Various astronomical instruments, books, prints, &c.

Digitized by Google

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	37	VIII.	204	XIX.	251
I. Part 2	79	IX.	208	XX.	259
II. Part 1	97	X.	220	XXI. Part 1 (separate).	302
II. Part 2	64	XI.	235	XXI. Part 2 (separate).	101
III. Part 1	125	XII.	243	XXI. (together).	151
III. Part 2	145	XIII.	255		
IV. Part 1	145	XIV.	442	XXII.	249
IV. Part 2	160	XV.	247	XXIII.	247
V.	173	XVI.	251	XXIV.	288
VI.	193	XVII.	239		
VII.	217	XVIII.	235		

In forming the table representing the state and progress of the Society, it has been found that, owing to the method hitherto followed of taking the preceding table for granted, various necessary corrections, such as deaths learned too late for insertion, changes of annual subscribers into compounders, &c., have been omitted. The consequence is, that in every item the table for 1856 represents the Society as rather larger than it really is: the total being 27 too great. The following table shows the list as corrected for February 1856, and as carried on to February 1857. In future the correctness of the starting list will not be assumed:—

	Compounders.	Annual Contributors.	Non-residents.	Patronesses, and Honorary.	Total Fellows.	Associates.	Grand Total.
February 1856	153	197	61	5	416	58	474
Errors	+4	+12	+5	+1	+22	+5	+27
Correct total, 1856...	149	185	56	4	394	53	447
Since elected	3	13	...	1	17	...	17
Deceased	−3	−4	−4	...	−11	...	−11
Removals	3	−2	−1	...	...	...	...
Expelled	...	−4	...	...	−4	...	−4
February 1857	152	188	51	5	396	53	449

The instruments belonging to the Society are now distributed as follows:—

The *Harrison* clock,

Digitized by Google

The *Owen* portable circle,
The *Owen* portable quadruple sextant,
The *Beaufoy* circle,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The *Lee* circle,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The Variation transit (late Mr. Shearman's),

are now in the apartments of the Society.

The Brass quadrant, said to have been *Lacaille's*,

is in the apartments of the Royal Society.

The remaining instruments are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Beaufoy* clock,
The two invariable pendulums, } to the Royal Society.

The other *Beaufoy* clock, to the Rev. J. B. Reade.

The *Wollaston* telescope, to the Rev. T. W. Webb.

At a General Meeting held after the ordinary meeting in December, it was determined to make the following alterations in the bye-laws relating to the award of the medal. Of the persons (if the plural number can be used) nominated, as under the existing law, in November, one is to be selected by the Council in December, as the person to whom, of all who have been nominated, it is most expedient to award the medal. At the following meeting, in January, the absolute claim of this selected nominee is to be considered on the simple question whether the astronomical labours specified in the minute of nomination are or are not worthy of the medal. Under the existing law, the members of the Council are all but required to vote on two questions at once, the question of relative merit and the question of absolute merit; and to combine these two questions in voting by ballot on the nominees, one after another. The inconveniences of this combination of questions showed themselves on past occasions in so striking a manner that the Council felt they had no alternative but to submit to the Society at large a proposal for an alteration in the bye-laws.

The medal for this year has been awarded to M. Schwabe, of Dessau, for the skill and perseverance exhibited in a thirty years' series of observations on the spots of the sun,—a series, which

Digitized by Google

has already contributed to the production of very remarkable results. The President will, at the close of this day's proceedings, enter upon the grounds of this award in the usual manner.

The Council have the satisfaction of announcing to the Society that the twenty-fifth volume of the *Memoirs* is now ready for publication. The subject-matter is of a varied character, and will be found in several respects to be eminently deserving of attention. A paper, by Mr. Main, on the dimensions of the rings of *Saturn*, contains the details of an investigation by that astronomer, which was briefly alluded to in the last Report of the Council. It is plainly demonstrated in this paper that, from the time of Huyghens down to the present day, no sensible change has occurred in the relation of the rings of *Saturn* to the body of the planet.

When we consider the high reputation of Mr. Main as an observer, the admirable instrumental means which he employed in the prosecution of his labours, and the extensive series of measures upon which his results are founded, we feel assured that the Society will agree with us in regarding the results deduced by him as forming an important contribution to astronomical science.

We owe, also, to Mr. Main a paper on the diameters of the other planets, which contains some interesting results. The definitive result for the diameter of *Venus*, when taken in conjunction with the value of its mass, as derived from other considerations, assigns to the planet a somewhat less density than it has hitherto been supposed to possess. It is a remarkable fact, that the evening measures of the disk would seem to indicate no sensible traces of irradiation. The researches on the diameter of *Jupiter* have led Mr. Main to a considerably less value of the ellipticity of that planet than has hitherto been assigned by observers. This conclusion, which has been confirmed by the measures of Mr. De La Rue and Professor Secchi, will, no doubt, suggest useful discussion on the relative advantages of the various micrometers employed in observations of this kind. It will also tend to throw some light on the physical theory of the satellites of *Jupiter*, in which the ellipticity of the primary plays an important part.

Perhaps there is no branch of astronomical science, which has opened a wider field of observation and research than the subject of double stars. The volumes of our *Memoirs* are peculiarly rich in contributions relating to this class of objects. We find in them the original exposition of the best practical method which has yet been devised for determining the orbit of a double star, and which we owe to one of the most distinguished ornaments of the Society. The observations, however, as might naturally be expected, are chiefly confined to the northern hemisphere. The volume of *Memoirs* for the past year contains a paper on double stars, by Mr. E. B. Powell, who has taken advantage of his residence at Madras to observe many of such objects, which

Digitized by Google

are not visible at any European Observatory. Mr. Powell has appended to his micrometrical measures a number of valuable notes, in which he has discussed the various circumstances relative to the orbitual movements of some of the more interesting binary systems recorded in his catalogue.

Mr. Ellis, one of the assistants at the Royal Observatory, Greenwich, has contributed a very interesting paper relative to the true interpretation of an inscription, which appears on some ancient tablets recently discovered in Egypt by the Rev. Mr. Stobart. Soon after their existence became known, these tablets were submitted to a careful examination by M. Brusch of Berlin, who arrived at the conclusion that the inscriptions represented a series of observed places of the five principal planets, and that the period of observation fell in the reign of the Roman Emperors, Trajan and Adrian. The attention of the Astronomer Royal having been drawn to the subject, he gave instructions to Mr. Ellis to scrutinise M. Brusch's interpretation of the inscriptions, with the view of ascertaining whether the conclusions at which he arrived were consistent with the theories of astronomical science. Mr. Ellis has executed the task assigned to him in a paper distinguished by careful research and skilful criticism. He has proved, beyond all doubt, in accordance with the views of M. Brusch, that the inscriptions indicate a series of places of the five principal planets. He also corroborates the conclusion arrived at by that *savant* with respect to the epochs of the places, but he differs from him in so far as he has demonstrated that, instead of being observed places, they are the results of calculation. The paper is eminently worthy of the attention of every person who takes an interest in the literature of our science.

Mr. Pritchard, in a short paper, has rectified a mistake in chronological astronomy, which appears to have obtained some currency in recent times. Dr. Ideler has asserted, in a well-known work, that certain conjunctions of *Jupiter* and *Saturn*, which occurred in the year 7 B.C., would satisfy the circumstances recorded of the star of the Magi; and this explanation of the phenomena of the star has been adopted by some subsequent writers. Mr. Pritchard, however, having submitted the places of both planets to strict calculation, found that, although these conjunctions actually did occur in the year 7 B.C., on none of those occasions were the planets sufficiently close to present the appearance of a single star; nor, even admitting this to be true, were they in the proper position at sunset to justify the supposition of their identity with the star of the sacred writings.

The volume of *Memoirs* closes with a note by Professor Smyth, containing the results of a discussion of a series of earth-thermometer observations prosecuted at the Observatory of Edinburgh between the years 1838 and 1854. These thermometers were originally established by the British Association, under the superintendence of Professor J. D. Forbes. The bulbs were buried in

Digitized by Google

the porphyry rock of the Calton Hill at different depths, the tubes rising to the surface, where the indications were read off by the aid of suitable scales. Professor Smyth has shown very satisfactorily, by a comparison of the mean results for each thermometer, that the temperature steadily increases towards the centre of the earth. He has also found traces of a secular inequality which, he is inclined to suppose, is so far indicative of the sun belonging to the class of variable stars.

With respect to the *Monthly Notices*, the Council have few remarks to make, in addition to what has been already stated at former anniversaries of the Society. The utility of this Journal in presenting a condensed view of the progress of astronomy in England, with an occasional reference to the state of the science in other countries, is now universally acknowledged; and it only remains for the Council to urge upon each individual member of the Society the desirableness of contributing towards its pages. Astronomy is a science of such vast extent as to offer a peculiarly wide field of selection to the amateur who may be desirous of devoting his attention to the cultivation of any of its branches. When we take into consideration the many excellent private observatories, which have been established in this country, it can hardly be doubted that much advantage would accrue to astronomy if their resources were more extensively employed in the careful execution of extra-meridional observations. Nor can the Council omit to remind the Fellows of the Society that many of them, who possess no appliances for the purposes of observation, are, notwithstanding, perfectly competent to execute the processes of calculation, which conduce to the advancement of astronomy. The *Monthly Notices* supply an easily accessible channel for disseminating the labours of both these classes of amateurs.

We have to regret the loss by death of the following Fellows:—Dr. George Butler; Admiral F. W. Beechey; Thomas Donkin, Esq.; Thaddeus Foley, Esq.; Rev. William Giles; Captain Thomas Graves, R.N.; Robert Arthur Graham, Esq.; Rev. John Phillips Higman; Rev. Samuel King; John Fletcher Miller, Esq.; William Lewin Newman, Esq.; Rear-Admiral Sir John Ross; Richard Wellesley Rothman, M.D.

Rear-Admiral Frederick William Beechey, F.R.S., who was one of the early members of this Society, earned his reputation by his conduct as an active officer, and by his skill as a scientific navigator. A son of the late Sir William Beechey, R.A., he was born in February 1796, and entered the Royal Navy in the summer of 1806. While serving as a midshipman on board the Astrea, of 36 guns, he bore a part in Commodore Schomberg's decisive frigate-action off the Isle of France, in May 1811. He afterwards served on the expedition to New Orleans, and was promoted to the rank of Lieutenant on the 10th of March, 1815.

Digitized by Google

Public attention having been drawn to Polar exploration, in January 1818, Lieut. Beechey obtained an appointment to the Trent, a hired brig commanded by the late Sir John Franklin, then a Lieutenant, and accompanied the expedition for northern discovery under Capt. David Buchan: of which voyage, Beechey published an account a quarter of a century afterwards. This attempt not having proved satisfactory, another expedition was fitted out under the command of the well-known Lieut. Edward Parry, and Lieut. Beechey was commissioned to the Hecla, in January 1819: this party having penetrated sufficiently into the Arctic circle to entitle them to the Parliamentary reward, he received the sum of 200*l.* as his portion. In 1821 he was appointed second Lieutenant of the Adventure, sloop-of-war, commanded by Capt. W. H. Smyth; and, in carrying out that officer's arrangements, he was landed at Tripoli with his brother and a selected party, to proceed from thence along the shores of the Regency, round the Gulf of Syrtis, through the Cyrenaica, and as far eastward as Dernah, in co-operation with the proceedings of the Adventure. This novel and interesting journey, which lasted till the end of July 1822, was performed entirely to the satisfaction of his captain; and the resulting details have since been given to the public in a volume entitled *Proceedings of the Expedition to explore the Northern Coast of Africa*, which was drawn up by Mr. Henry Beechey, and appeared in 1828.

Meantime Lieut. Beechey had been advanced to the rank of Commander in the Navy, and in 1825 was commissioned to the Blossom, of 24 guns; with directions to sail round by Cape Horn, and proceed to Behring's Strait; there to act in concert with the differently-directed movements of Parry and Franklin in their exertions to discover a north-west passage. This important voyage occupied three years and a half; during which they visited many climes, and made numerous nautical discoveries of great interest: and after traversing 73,000 miles, the Blossom arrived at Spithead with a freight of 1,500,000 dollars on board. She anchored in September 1828, and her captain had the pleasure to find that he had been posted exactly a year before. A very clear and interesting account of this undertaking was soon afterwards published, under the title, *Narrative of a Voyage to the Pacific and Behring Straits, to co-operate with the Polar Expeditions.* This book is a valuable addition to the standard works of our circumnavigators.

In 1835 Captain Beechey was appointed to the Sulphur, of 8 guns, for the purpose of surveying the west coast of South America; and a schooner, the Starling, was fitted as a tender. But at Valparaiso his ill-health compelled him to resign the command, and he returned home in the summer of the following year. But with the renewal of strength, he was at work again; and in 1837 joined the African, steamer, for the purpose of surveying on the coasts of Ireland and the opposite shores of England. This severe service was not only productive of some useful charts, but

Digitized by Google

also afforded many elucidations of the Channel tides: and he continued those labours in the Lucifer and the Firefly, also steamers, till he was called by the Government to constitute and superintend the Marine Department of the Board of Trade; a station, wherein he was zealously employed until his death, on the 29th of last November, when he closed a very useful and meritorious career. He had been promoted to the rank of Rear-Admiral on the 1st of September, 1854; and, at the time of his demise, filled the office of President of the Royal Geographical Society.

Thomas Donkin, born near Hexham, May 28, 1776, was a member of a family in which scientific talent is frequently displayed. His brother, Bryan Donkin, was well known to the world, and needs no commemoration in this room; his son is the Savilian Professor of Astronomy at Oxford, well known by his treatment of the most difficult mathematical subjects. The father of Thomas Donkin was a farmer and land-agent, and the son had little education, except what he gave himself. He took especial interest in every application of science, and acquired so much knowledge, and so wide a field of exercise, that there were few crafts, from that of a physician to that of a blacksmith, in which he could not have been useful on an emergency. His favourite pursuits were music, chemistry, and astronomy; and he was in the habit of furnishing his neighbourhood with the true time, having a small observatory with a transit and clock. He died January 19, 1856, in his eightieth year, leaving behind him a high character for uprightness as well as knowledge and intelligence. He had been a Fellow of this Society since 1823.

William Giles was born at Dartmouth, in Devonshire, on Dec. 30, 1798. It is told of him, that at eleven years he could remain in the water from two to three hours without touching anything but the water itself, and it was no uncommon thing for him to dive from the side of a loaded brig, pass under her keel, and come up on the other side. After eight years' residence at Oxford, he settled in Chatham, where he conducted a school. The celebrated Charles Dickens was one of his pupils. The science of astronomy became his favourite study, on which he delivered several courses of lectures at Chatham and elsewhere. After several changes of residence, he died at Chester, where he had settled for his health, Sept. 30, 1856. He was highly respected by his friends, as a man of strong intellect and high character.

Robert Arthur Graham (born May 14, 1805, died March 22, 1856) was one of the Fellows who came into the Society when the Mathematical Society was made a part of our body. He had been long a member of the Mathematical Society, and was a lover of science, and highly respected by those who knew him.

Digitized by Google

Captain THOMAS GRAVES, R.N., son of the late Captain Thomas Graves, also of the Royal Navy, was born in November 1802; and being intended for maritime life, was sent, after a preliminary education, as a student to the Royal Naval College at Portsmouth, in March 1816. Here he conducted himself with such attention and ability, that in December 1817, he was sent, as a College Volunteer, into the Bulwark, of 74 guns, a guard-ship, then commanded by his father. He shortly afterwards sailed in the Ister to the Newfoundland station, and served in the Creole and Hyperion frigates, in South America. In each of these ships an anxious desire for improvement in all branches of professional knowledge was so evident, as, on his return to England, to obtain for him a recommendation from Admiral Sir George Cockburn to Captain W. H. Smyth, to receive him on board the Adventure, sloop-of-war, as an Admiralty midshipman. In this vessel he acquitted himself with such zeal and intelligence, that after she was paid off in November 1824, he was retained by his captain till October 1825, to assist in getting up the charts of the Mediterranean survey in the Admiralty Office. In the meantime he had undergone his examination for a commission with such credit, that the passing captains felt themselves called upon to give him, besides the usual formal document, an extra certificate, of which the following is a copy:—

"These are to certify that Mr. Thomas Graves appeared before us for the purpose of being examined, touching his qualifications to serve as Lieutenant in his Majesty's naval service; and, on the perusal of his logs, and his being examined accordingly, he appeared to us to merit this additional mark of our highest approbation of his ability; and we further beg to recommend a perusal of his logs, which show a degree of care and attention worthy of imitation.

"Given under our hands, on board H. M. S. Rochford, Malta, 20th of January, 1823.

(Signed) "C. M. SCHOMBERG,
W. C. JERVOISE,
W. H. SMYTH,
} Captains."

The Adventure being commissioned for an exploring voyage to the Strait of Magellan and the adjacent shores, under Captain P. P. King, that officer, on the strong recommendation of Captain Smyth, received Mr. Graves as his Assistant-Surveyor. In this capacity he served from October 1825 to November 1830, two years of which he was in command of the Adelaide schooner, tender to the Adventure; during which time the Cockburn and Barbara channels, as well as much of the coast of those regions, were surveyed by him conjointly with Lieut. Skyring, who had also been brought forward by Captain Smyth for that employment. While thus actively occupied, Graves received somewhat tardily his first commission as lieutenant; it was dated 30th of April, 1827.

In July 1831, Lieut. Graves — being then on a visit to his parents at Castle Dawson in the north of Ireland — received an appointment to execute, in conjunction with the Ordnance Sur-

Digitized by Google

veyors, a plan of Lough Neagh; which he completed very satisfactorily in about ten months. He was then commissioned to the Mastiff, gun-brig, and sent out to the Archipelago, there to assist Captain Copeland in examining the islands and coasts; but his commander having resigned on account of ill-health, Graves was selected to conduct that interesting and valuable work in 1836. And most ably did he perform this great duty: for ten years he carried it on in the Beacon sloop, and when she was no longer sea-worthy, the Volage, corvette, was sent out to receive his pendant. In this ship he was completing his labours with such celerity, that the end of the expedition appeared to be in view, when the ship was most unexpectedly and peremptorily ordered to England, where she was paid off in December 1850. This inscrutable measure was one of surprise, not only to the service, but to Sir Francis Beaufort, the Hydrographer, himself; for he addressed a consolatory letter to Captain Graves, praising the prompt and vigorous energy which had characterised his whole career, and stating, — "We have worked so long together, and with so much harmony and fellow-confidence throughout, that the cessation of all further surveying intercourse really afflicts me,— and what makes a far greater impression than any personal feelings is the heavy blow which will be sustained by that branch of the service to which your persevering labours did so much credit."

Some of the results of these "persevering labours" are shown in upwards of fifty Archipelagan charts and plans, of such elaborate detail and accuracy that they are of the highest use, as well to the historian and scholar as to the navigator and traveller. Nor were these the only efforts of his attention: anxious to serve all branches of science, he *enlisted*, at his own responsibility and expense, in 1841, the late lamented naturalist, Professor Edward Forbes; who remained on board as his friend and companion, busily occupied for nearly two years. Nor was Forbes the only contributor to knowledge thus chosen; and the aid which he afforded to the investigation of Lycia and its antiquities has been warmly acknowledged. He received, through Sir Edmund Lyons, the distinct thanks of the Greek Government for his successful exertions in extinguishing an alarming fire at the Piræus in the year 1839; and the Sultan, Abdul Medjib, personally presented him with a handsome snuff-box, richly mounted in diamonds, in recognition of the benefit of his services both to navigation and commerce.

After his useful employment had been so unexpectedly and so injuriously interrupted at head-quarters, the mortified officer returned to Valetta, where, by the advice and documentary aid of Captain Smyth, he proposed to draw up a "Sailing Directory" of the whole Mediterranean Sea, for which his long acquaintance therewith peculiarly adapted him. The warm sympathy, however, of all ranks attended Captain Graves; and Sir William Reade, the present Governor, handsomely offered him the good post of

Digitized by Google

Marine Magistrate and Superintendent of the ports of Malta. This was gladly accepted, and he carried on the onerous duties of the office with honour and credit for upwards of three years. It happened that in consequence of a glaring breach of the enacted regulations, one Giuseppe Meli was brought before the Captain, and, after due inquiry, was sentenced to have his boat hauled up for a fortnight — a sentence in just accordance with the due discharge of the magistrate's official duty. But the hardened culprit loudly vowed vengeance, waylaid Graves, and stabbed him in the principal street in Valetta at noon-day. This was on Monday, the 25th of last August, after which the victim lingered till Thursday, when he expired. His remains were conveyed to their final resting-place on the evening of the following day, attended by the Governor, the Admiral, and all the principal authorities; and the mournful procession to the English cemetery was joined by a long line of officers, merchants, and inhabitants. From his great moral worth and benignant disposition he was very popular; his sad and untimely fate, therefore, spread a general gloom over the Maltese community. The murderer escaped full punishment by the perverse verdict of the Maltese jury, which decided that Captain Graves died a natural death.

Although, as we have shown, Captain Graves was almost constantly abroad, he evinced his love of science by becoming a Fellow of this Society so far back as January 1826; and he was one of the original Members of the Royal Geographical Society.

John Phillips Higman was born in Devonshire, October 26, 1792, and was originally intended for the medical profession. His turn for mathematical pursuits induced his friends, about 1812, to send him to Trinity College, Cambridge; Mr. Babbage was, we are informed, one of those who, on a casual acquaintance, discovered his powers, and advised the change of plan. He graduated in 1816, and was third Wrangler, following Mr. Whewell in the list of honours. He afterwards obtained a Fellowship, under circumstances of a rather unusual kind. At his first trial, his classical knowledge was so indifferent, that he received a friendly hint, sometimes given in such cases, that it would be useless for him to try again. This hint he used as follows: giving out that he was going down into Devonshire, he secreted himself in a cottage at Grantchester, near Cambridge, and read classics for twelve hours a-day, never walking out till dusk. The consequence was, that at the next trial he gained the Fellowship, and was very high, if not the very first, on the list. In 1822 he was appointed one of the tutors of the College, which post he held till 1834, when he obtained the College living of Fakenham. He died, August 5, 1855, and Churchmen and Dissenters united to pay the last tribute to his remains; for, though his college life exhibited faults of a very grave kind, to which we cannot avoid allusion, as their consequences were notorious, he gained the love and the respect of his flock as a parish priest, though the impressions

Digitized by Google

under which he commenced the discharge of his duties among them could not have been so favourable as is usual in the case of men of his academical celebrity. As a tutor, Mr. Higman was distinguished by the excellence of his lectures, and by his singular power of sufficient explanation in few words. His mathematical education had been that mixture of the old geometry and the modern analysis by which a good teacher is best formed: and the perfect clearness of his own head would not allow any confusion in the head of a pupil to escape him. One of his old pupils, now an experienced teacher, informed us that one of the most useful lessons he ever received, whether as a student or as a future teacher, was given thus.. The pupil had presented a written exercise in which were the words, "It is evident," on which Mr. Higman remarked, "Mr. ———, whenever a student tells me a thing is evident, I know he doesn't see it." It is much to be regretted that Mr. Higman did not apply himself to elementary writing: he published nothing but a small (anonymous) syllabus of the Differential and Integral Calculus, which, though only a syllabus of propositions with brief remarks, will enable the reader in some measure to verify for himself the character of his teaching here given.

JOHN FLETCHER MILLER, Ph. Dr., F.R.S. &c., was the eldest son of William Miller, Esq., of Whitehaven. He was born at Whitehaven in the year 1816. From his early boyhood he manifested a remarkable predilection for scientific pursuits, and immediately on leaving school he obtained a set of meteorological instruments, the indications of which he registered with undeviating regularity for a period of nearly a quarter of a century. About the year 1844 some singular facts relating to the meteorology of the Lake district of Cumberland and Westmorland came to his knowledge, which led him to enter upon a systematic and extensive examination of the subject. For several years he had from 20 to 30 rain-guages, and a number of thermometers, placed at various points throughout the lake and mountain district, and obtained results which have filled meteorologists with amazement. These results it is not our province here to discuss, suffice it to say, that they contain the only extensive observations of rain in mountain districts, and are fully discussed in a series of papers in the *Transactions* of the Royal Society.

From his youth he was ardently attached to astronomy, and was exceedingly well informed on many branches of the subject. In the summer of 1850 he erected an elegant private observatory, which he furnished with one of Cooke's admirable six-foot equatoreals. This instrument he devoted chiefly to the micrometrical measurement of a list of double stars taken from Admiral Smyth's *Cycle*. The results obtained are appended to a paper in the twenty-second volume of our *Memoirs*, by Mr. Isaac Fletcher, F.R.S., on the "Results of Micrometrical Measures of Double Stars, made at Tarn Bank." Though the stars measured are not

Digitized by Google

numerous, the results are very valuable from their accuracy, and from the fact that they relate chiefly to stars of an ascertained binary character. He possessed the elements of a first-rate observer,—excellent eye-sight, perseverance, and dexterity of manipulation.

He was well informed, also, in many other branches of science, and in anatomy and physic he possessed an amount of information which would not have disgraced a regular practitioner. He maintained an extensive correspondence with the leading meteorologists of the day, and in his early death the science of meteorology has lost one of its brightest ornaments.

He was elected a Fellow of this Society in 1849, and of the Royal Society in 1850. He died July 14, 1856.

Sir John Ross, K.T., C.B., &c., born on the 24th June, 1777, at Balsaroch, Co. Wigton, was the fourth son of the Rev. Andrew Ross, Minister of Inch. He entered the Royal Navy in November 1786, as first-class volunteer on board the Pearl, 32, Capt. Hon. Seymour Finch, and served in the Mediterranean until 1789. He was then employed in the Channel, on board the Impregnable, 98. Mr. Ross afterwards went into the merchant service, in which he remained for several years. In 1799 he sailed as midshipman on board the Weazel, sloop, Capt. William D'Urban, which vessel formed part of the expedition to Holland. In 1802 he was employed as acting-Lieutenant on board the Clyde, 38, and subsequently he served on the home and Baltic stations as midshipman in the Zealand, Kite, and Grampus, all flag-ships of Sir James Saumarez. Mr. Ross then commanded the Carteret cutter, with the rank of acting-Lieutenant, and in March 1805 was appointed Lieutenant of the Penelope, 36, Capt. Robert Broughton. He served as Lieutenant in the Surinam, Prince of Wales, 98, Hibernia, 120, Diomede, 50, and Victory, 100, all flag-ships of Sir James Saumarez. Whilst Lieutenant on board the Surinam Mr. Ross was severely wounded in the head and body, for which he was granted a pension of 150*l.* per annum. In 1808 Mr. Ross was sent on board the Swedish Admiral's ship, and acted as Captain of the Swedish Fleet. He was promoted to the rank of Commander in 1812, and appointed to the Briseis, 10, and employed on the Baltic and North Sea stations. In the Briseis, Commander Ross captured a French privateer, "Le Petit Poucet," and drove three other privateers on shore. He afterwards commanded the Acteon employed in the North Sea, and in 1815 was appointed to the Driver, also upon the North Sea station.

At the end of the year 1817 the Board of Admiralty resolved to despatch an expedition in order to ascertain the existence, or non-existence, of a North-west passage, and Capt. Ross was selected to command it. He was superseded from the Driver, and appointed to the Isabella, a ship of 385 tons, which, together with the Alexander of 252 tons, had been chosen for this voyage. The Alexander, the consort of the Isabella, was commanded by Lieute-

Digitized by Google

nant W. E. Parry, who afterwards became so distinguished for his discoveries and services in the Arctic Regions. The expedition sailed from the Thames in May 1818; after meeting with many difficulties and dangers in his progress, Capt. Ross was able to make the complete circuit of Baffin's Bay, and to return homewards in time to avoid the necessity of wintering in the northern regions.

Capt. Ross's own remarks on the fruits of this voyage are characteristic of the kindly feelings by which he was habitually animated; he says, "In re-discovering Baffin's Bay I have derived great additional pleasure from the impression, that I have placed in a fair light, before the public, the merits of a worthy and able navigator, whose fate, like that of many others, it has not only been to have lost, by a combination of untoward circumstances, the opportunity of acquiring during his lifetime the fame he deserved; but, could he have lived to this period, to have seen his discoveries expunged from the records of geography, and the Bay with which his name is so fairly associated treated as a phantom of the imagination. In 1818 I circumnavigated Baffin's Bay, and, by this means, restored to our charts, whence they had been expunged, the valuable discoveries of that great navigator whose name it bears; correcting them only where the imperfection of his means, and other circumstances, had left errors of small importance compared to what he had effected."

Commander Ross was promoted to the rank of Captain on the 7th Dec., 1818, immediately after his return from the voyage to Baffin's Bay.

His attention was constantly directed to the subject of discoveries in the northern regions. In the early part of the year 1829, with the liberal assistance of Mr. Sheriff Booth, better known as Sir Felix Booth, he purchased the Victory, a steam-vessel of 150 tons, which had been employed as a packet between Liverpool and the Isle of Man, with the intention of exploring. This was entirely a private expedition, though sanctioned by the Board of Admiralty. It was undertaken in order to solve, if possible, the question of a North-west passage from the Atlantic to the Pacific Ocean, particularly by Prince Regent's Inlet. The Victory sailed from England in May 1829, under the command of Sir John Ross, and with Sir James Clark Ross (then Commander Ross) second in command. The total number on board the Victory was only twenty-four persons. Having visited the beach where H.M. ship Fury had been abandoned, the Victory reached Cape Garry in August 1829, from whence the discoveries of this voyage commenced. Taking a south-west direction they proceeded to explore a hitherto unknown country. Owing to the ice, the shallowness of the water, the rapidity of the tides, the tempestuous weather, the irregularity of the coast, and the numerous inlets and rocks for which it is remarkable, the progress was no less dangerous than tedious. Yet they succeeded in penetrating below the latitude of 70° north, in longitude 92° west. In October

Digitized by Google

1829 their further progress was arrested by an impenetrable barrier of ice, where, however, they found an excellent wintering port, which was named Felix Harbour. The Victory was detained by the ice in the immediate vicinity of this port—there being no possibility of moving her farther than four miles during the summer of 1830, which Sir John Ross described as being beautifully fine, but extremely unfavourable for navigation.

In the autumn of 1831 they could only gain a distance of fourteen miles from the port of the preceding winter. In this harbour, which was called Victory Harbour, but which has since been named Victoria Harbour, it was considered necessary to leave their ship and endeavour to return homewards in the boats. They left the Victory on the 29th of May, 1832. The summer and autumn of 1832 were usefully employed, although the party was exposed to severe hardships and extreme danger. They reached the north-east point of America, situated in lat. 74° N., and long. 90° W.

Want of provisions and the approach of winter obliged them to make for the Fury beach, which they reached on the 7th of October, 1832, making a little more than three years from the time they passed that spot on their outward voyage. Here they were forced to remain, and this dreadful winter was passed by the exploring party in a hut they erected, about thirty-two feet long, which was speedily covered with ice, and they became, as Sir John Ross expressed it, the inhabitants of an iceberg during one of the most severe winters hitherto recorded—their sufferings aggravated by want of bedding, clothing, and animal food. The party were unable to move from hence until the 8th of July, 1833, when they set out on their return by Cape York, and Navy-Bay Inlet, near to which they had the good fortune to fall in with the Isabella, the same ship in which Sir John Ross made his voyage in 1818. From hence Sir John Ross and those under his command returned to England in the Isabella, arriving in October 1833. The courage and energy of all composing this expedition, aided more particularly by the science and perseverance of Sir James C. Ross, were the means of adding a large tract of hitherto undiscovered country to geography. It was named Boothia Felix, in compliment to the munificent patron of the expedition.

The discovery of the Magnetic Pole must not be left unnoticed. A committee of Members of the House of Commons, assisted by scientific men of eminence, appointed to investigate the results of this expedition, declared, that they saw no reason to doubt that Captain Ross nearly approached, and that Commander Ross actually reached, the Magnetic Pole.

Sir John Ross received the honour of knighthood together with the Companionship of the Bath, on the 24th December, 1834, directly after his return from this unparalleled voyage. In March 1839, he was appointed British Consul at Stockholm, where he remained several years. The following are his war services as detailed in Allen's *New Navy List.*

Digitized by Google

" Sir John Ross was Midshipman of H.M. Ship Weazel, and wounded when serving with the army in the Texel Expedition in 1799. He was severely wounded when destroying a vessel under a battery near Cape Frehel, when his boat was sunk by a shot. In a boat of the Weazel he blew up the wreck of the Jason, stranded near St. Malo. When commanding the Carteret, cutter, he was wounded in destroying a French gun-brig in the Bay of Dilcette in 1805. When Senior-Lieutenant of the Surinam he was dangerously wounded in four places, in defending a prize from the attacks of two gun-boats, under the batteries of Bilboa in 1806."

He was the author, among other works, of *Letters to Young Senior Officers, Memoirs and Correspondence of Admiral Lord de Saumarez,* and a *Treatise on Navigation by Steam.* He was promoted to the rank of Rear-Admiral in July 1851. Sir John Ross was elected a Fellow of the society in January 1821. He attended the meetings regularly, and was much esteemed by the Society for his frankness and his talents. He died in November 1856.

We have not been able to procure any details respecting the late RICHARD WELLESLEY ROTHMAN, M.D. He graduated at Trinity College, Cambridge, with high honours, in 1823. He obtained a Fellowship, and after some years was appointed one of the two lay fellows, by which he was enabled to preserve his fellowship without taking orders. Law and medicine are the presumed studies of the two lay fellows, but Dr. Rothman complied with the founder's intention, and actually graduated in medicine. He lived mostly in college, employed in study, until about 1837, when he was appointed Registrar of the newly-founded University of London, in which post he remained till his death, which took place in the last spring. He attended especially to astronomy, and was the author of the *History of Astronomy* in the Library of Useful Knowledge,—a learned and useful work, especially in ancient astronomy, to which he had paid great attention. Dr. Rothman was a member of our Council so long as his health and avocations permitted; and was at one time our Foreign Secretary. His retiring manners and silent temperament prevented his acquirements from making any show, but those acquirements were sound and extensive, and caused him to be held in high respect by those who knew him well.

No remarkable change has been made during the past year in the instruments or the operations of the Royal Observatory. The volume of the *Observations* for 1854 has been published, and is remarkable as containing, besides the usual amount of work, two valuable appendices. One of them is the catalogue of 1576 stars for the epoch 1850, compiled from all the meridian observations made in the six years commencing with 1848 and ending with 1853. This catalogue, it is hoped, will be valuable to astronomers not only from the *number* of stars whose places are accurately

Digitized by Google

determined, but from the nature of the various classes which have been observed for particular purposes. It contains, firstly, the places of all stars in the British Association *Catalogue* from the first to the fourth magnitude inclusive, that is, it gives with great precision the places of all the conspicuous stars in the northern heavens visible at Greenwich, which may be useful for nautical, or geodetic, or other purposes. It contains, also, the places of a selected list of stars for the determination of clock-errors, additional to those given in the *Nautical Almanac*, and extending with tolerable regularity through the twenty-four hours of right ascension. Thirdly, there is a small number of stars near the north pole, which will be useful for the determination of azimuthal errors of the transit-instrument, when *Polaris* and the other close circumpolars of the *Nautical Almanac* are not visible.

The other appendix to this volume consists of the description of the reflex zenith tube, of which the principle of construction is tolerably familiar to the Fellows of this Society. Though perfect in theory, this instrument had for some time after its erection partially failed in practice from the difficulty of keeping the surface of the mercury free from disturbance, especially when the star passed the meridian during the business-hours of the day. Its first position, near the entrance-gate of the Observatory, being found particularly unsuitable in this respect, it was removed to another position a little to the west of the transit-circle room, where, it was hoped, it would be tolerably free from disturbance, and was mounted in a way similar to its former mounting, that is, with the trough of mercury resting on a slab of stone, which was itself laid upon a considerable mass of sand. It soon appeared, however, that the disturbances were not at all diminished; and, as a second experiment, a pit was dug to the depth of about ten feet, considerably below the foundation of the walls of the building. From the bottom of this pit a pier was built up quite isolated from the building, and the mercury was placed on a flat stone laid on the top of it. This arrangement did not appear to produce much effect, and for some time it appeared difficult to determine upon any mode of support likely to be successful. At length it was determined to try the plan of suspending the mercury trough from a frame having only a mediate connexion with the ground. For this purpose the well was filled with incoherent rubbish, and a stage was placed upon it for the support of the mercury trough, and by this arrangement the tremor was sensibly diminished. From this first stage was then suspended, by means of vulcanized caoutchouc, a second; and from this second in like manner, a third stage; and on the latter the mercury-trough was laid. By this arrangement the tremor was completely destroyed, but there still remained the oscillation of the mercury to be got rid of. This was effected by connecting the trough horizontally in two directions by shreds of vulcanized caoutchouc with the first or fixed stage; and by this means both tremor and oscillation of the mercury were found to have been completely got rid of. Since that

Digitized by Google

time observations have been made with perfect ease at every transit of the star when the sky has been clear, even in full daylight, and in one recent instance γ *Draconis* was observed when it passed the meridian at the same time as the sun. The instrument is now sensibly perfect both in theory and practice, and we expect from it a series of observations of γ *Draconis*, which will ultimately be of considerable value.

No alteration worthy of mention has been made in the galvanic arrangements of the Observatory, either in the application to transit-observing, or in the distribution of time. One clock at the Post-office in Lombard Street has been kept constantly regulated once every day by the normal clock at Greenwich, and the other clocks at the same office will very shortly be put in circuit. The usual operations connected with the galvanic manipulations have become very easy by the constant practice of the assistants employed, and whenever failures occur the sources of them are readily detected and corrected.

In the photographic arrangements no important change has been made, but the attention of the Superintendent of the Magnetic Department of the Observatory is constantly directed to improvements in the processes for preparing the photographic paper, and in securing still better traces of the results. An account of the whole process employed at present will be found at the end of the Meteorological Observations in the volume for 1855.

The works in connexion with the mounting of the great equatoreal at Greenwich have been progressing. The foundation-walls of the building were completed before the commencement of the winter, and in this state they have been left covered up for protection from the frost for the present. The castings for the mounting are in progress under Messrs. Ransomes and Simms, the mounting itself being somewhat similar in form to that of the Northumberland equatoreal. An object-glass of 12½ inches aperture is expected from Merz and Son of Munich, but it has not yet been received.

The Astronomer Royal is understood to be still occupied with investigations relative to the eclipses of Agathocles, Thales, and Larissa, and to have identified the latter eclipse with the date — 556, May 19. The simultaneous computation of these three eclipses, it is hoped, may prove valuable both for astronomy and for the geography of ancient history: inasmuch as the enchainment of the three eclipses by one system of solar and lunar tables not only requires certain possible corrections (of minute amount) to the elements of the tables, but also defines with some degree of accuracy the limits of the districts over which the shadows must have passed.

The formation of standard end-measures from standard line-measures has been accomplished in a perfectly satisfactory way, by taking advantage of an ingenious suggestion of Mr. W. Simms, jun. The Society will be glad to learn that the essential parts of this troublesome work are now completed. An apparatus has been

Digitized by Google

prepared for the Exchequer Office for verifying with very considerable exactness the divisions of ordinary divided scales, on several systems of subdivision: and another apparatus is in hand, for the same office, for testing with a degree of accuracy that has never been attempted there, the correctness of the total length of end-measures.

At the Radcliffe Observatory the principal work during the year has been the continuation of the Catalogue of Remarkable Objects, which was begun in 1854. The Circumpolar Catalogue is quite finished, but it has been thought desirable to annex to the comparison with Groombridge the mean dates of his observations. Groombridge's manuscripts have been some time in Mr. Johnson's hands, and the dates have been nearly all copied. The sixteenth volume of the Radcliffe Observatory will appear in the course of a few weeks.

At Cambridge Professor Challis has prosecuted as formerly the observations of the small planets and of zodiacal stars. He has continued his attention to the adjustments of the transit and mural circle, with the view of eliminating by optical means the errors due to changes of the material. Since the publication of the Report Mr. Challis has communicated to the Editor of the *Astronomische Nachrichten* his intention to observe more particularly a selected number (eight) of the minor planets, following in this respect the course taken at other observatories. By this arrangement the distraction of having to attend to several at the same time is avoided; but it is not found that the labour of observing is much lightened, as the selected few are pursued into difficult positions in order to get as large a number of observations as possible.

Last autumn he again went through a series of measures (which is intended to be annual) to eliminate the effect of the forms of the transit pivots. The result accorded with those before obtained, and afforded additional evidence of the necessity of getting rid of this source of error prior to any exact determination of terrestrial longitude.

He also completed, last autumn, a series of determinations of the effect of flexure of the large mural circle, for positions of the telescope separated by intervals of 5° and 10°. This set was taken after particular precautions were adopted to get rid of any effect of variations of temperature, so that the measured effect might be solely due to flexure. The maximum angular amount was scarcely more than 0″·5, which is less than the amount given by direct and reflexion observations of stars. Mr. Challis thinks that in the latter method the sudden change of position of the circle, combined with variations of temperature from point to point, has some effect. He proposes, as soon as he can get time, to communicate to the Society the details of this experiment, which he believes is of a novel kind.

Mr. Challis has recently presented to the Society a collection

Digitized by Google

of the Reports made by the University Syndicate on the Observatory, from the beginning of his tenure of office. These Reports will in future be presented at the time of printing. They may, perhaps, have been hitherto kept back as being considered only of local importance. But the Council would remind all who are connected with any serial publication on astronomy, that such publications will be in time future, as they now are for time past, the only means of settling points of history, and the links between statements, of which the connexion would otherwise be difficult, or even impossible. All such publications ought to be preserved in the Society's library.

At Edinburgh the volume of Observations to the end of 1854 is completed, and will soon appear. A second assistant—an addition to the observatory much wanted and long expected—will probably soon be appointed. The history of the Edinburgh Observatory for the past year would be incomplete without special notice of the remarkable expedition to Teneriffe, made by Professor Piazzi Smyth, in the course of last summer. Of the energy displayed in this undertaking, the Council cannot speak too highly; nor can they doubt that the results will be valuable and lasting. The following brief notes will be most interesting to the Society, which, in common with the public at large, has had as yet but little information, owing to the official necessity of waiting until the account of the whole had been forwarded to the Admiralty. Professor Smyth is desirous of repeating his work. The Captain-General of the Canaries has written to express his full approbation and good wishes: and Mr. Stephenson and others have volunteered to repeat the loans which so largely contributed to the past success.

The origin and object of this expedition were first noticed in the Report to the Board of Visitors, by the Astronomer Royal for Scotland, in November 1852.

The plan was recommended by the Astronomer Royal (G. B. Airy) to the Admiralty in March 1856, and at once allowed by Sir C. Wood, the First Lord, on this footing, viz. that Professor Smyth should be furnished with a certain sum of money, and should be left to carry out in his own way the novel sort of inquiry of "How much can Astronomical Observation be improved by the Elimination of the lower third part of the atmosphere?"

Sir C. Wood and Captain Washington (hydrographer) behaved most liberally to Professor Smyth. His first estimate of the sum required was 300*l.* He was asked if that was not too small a sum: and being further advised to take out a larger and better telescope than the one at first contemplated, he sent in a new estimate for 500*l.* This increased sum was *instantly* placed at his disposal, with the only injunction that it was not to be exceeded. The conduct of the Board of Admiralty requires no praise at our hands, and we are confident it will be appreciated by public opinion.

Digitized by Google

April and May 1856 were spent in making preparations. Meanwhile lists of suggestions for all sorts of additional observations over and above those of the expedition, came in from different scientific societies and individuals, through the Admiralty, enough to entail the carrying out of many observers, and the expenditure of much money. But Professor Smyth determined to abide by his promise not to exceed his estimate. Nevertheless he was anxious to do something for the suggesters, and was in great straits until he was enabled to extend his operations, without further expense to the Admiralty, through the liberal loans made to him for the service of the expedition by various private individuals, namely:—

1. Actinometer, magnetometer, two radiation thermometers, electrometer, spectrum apparatus, and polarimeter. By G. B. Airy.

2. Grand equatoreal, telescope 12-feet focal length, 7·5-inches aperture, with clock motion, &c. By H. L. Pattinson, Esq. of Newcastle-on-Tyne.

3. Quartz train for spectrum. By Prof. G. G. Stokes.

4. Mountain barometer and six thermometers. By Dr. Lee of Hartwell, who also offered a large telescope, but it was declined, another being already supplied.

5. Mountain barometer, and four thermometers. By J. Adiè, Esq. of Edinburgh.

6. Thermomultiplier. By J. Gassiot, Esq.

7. Four barometers, twelve thermometers, and hydrometers, with blank books and maps. By Captain Fitzroy, on part of Board of Trade.

8. Four chronometers. By the Hydrographer to the Admiralty, Captain Washington.

9. Double sextant. By Admiral Beechey.

10. Polarization appliances. By the Rev. Baden Powell.

11. Plane speculum. By J. Nasmyth, Esq. C.E.

12. Eye-pieces and adaptations to equatoreal. By T. Cooke, Esq., of York.

13. Lastly, by R. Stephenson, Esq. M.P., was made the loan of his yacht the Titania, of 140 tons, and with a crew of sixteen men, for the voyage out and home, and during the whole period of the expedition. "Four months," said he, "do you expect to be away; well, then, I will send down this evening an order to the captain to have provisions for that time put on board; and the yacht shall be ready to sail at any time you like on twelve hours' notice: and when you get to Teneriffe you can take any of the men who can be useful to you up the mountain."

And Professor Smyth acknowledges with pleasure, that for the whole four months the captain and crew followed out in letter and spirit Mr. Stephenson's instructions, that they were to attend to Professor Smyth as though he were Mr. Stephenson.

Sundry other instruments were furnished by the Edinburgh

Digitized by Google

Observatory; amongst them the 5-foot equatoreal presented some years ago by the late Rev. R. Sheepshanks.

The best thanks of the astronomical world are due to Lord Clarendon for his passports, and his letters to the officials connected with his department abroad; and to the English Custom-house Officers; also to the Spanish Ambassador, Don Antonio Gonzales; and to Admiral Manners, for letters of introduction and recommendation to the Captain-General and many in authority at Teneriffe.

Professor Smyth set sail in the Titania on the 24th of June, with the run of the whole yacht, excepting those cabins in which were stowed his seventy-nine packages of instruments and camp-equipage.

On the voyage his "free-revolver" stand for a telescope at sea was tried, and found perfectly successful, a distant object remaining bisected in the field of view under any amount of rolling and pitching of the vessel: the sailors saw and confessed the powers of the new apparatus, and took kindly to it.

He arrived at Santa Cruz, Teneriffe, on July the 8th. From thence the yacht carried the goods round the island to Orotava, the most convenient port for the Peak.

The lowlands of Teneriffe were found to be bad for astronomical purposes by reason of the abundant clouds of the trades, and the violence of the wind in many parts.

From July the 14th to August the 20th he occupied Mount Guajara (28° 12′ N., 16° 38′ W.) 8843 feet high, his party including the carpenter and the second mate of the yacht, besides sundry Islenos.

They found themselves there above the trade-wind cloud, and all the cumuli, cumuloni, and cumulostrati, which appear daily below. But they were not above the thinner sorts of clouds, as cirri, cirrocumuli, and some cirrostrati, which appeared about one day in five.

The mountain sky was therefore very favourable as regards freedom from clouds. The climate was also remarkably free from wind, for a mountain-top, by reason apparently of its being nearly between the line of "wind and water" of the lower N.E. and the upper S.W. winds. The temperature was moderate, from 70° by day to 40° at night. The dryness was excessive, both by night and by day; a depression of the dew-point to the extent of 50° was not unusual, 56°·4 has been observed; 40° was an average quantity, and less than 30° was rare; and all this when the lower country and the sea around were covered in by a dense bed of clouds. The electricity was always resinous, and never abundant. The radiation of the sun was fierce, mounting above the graduation of the instruments, and with the temperature reading $180° + x$; without the temperature it was $110° + x$, and the value of x may be 10°, or may be 20°. The progress of radiation was sometimes observed at 15-minute, sometimes 5-minute, and sometimes 1-minute intervals throughout the 24 hours. Radiation with

Digitized by Google

the moon was perfectly sensible to the thermomultiplier without any other condensation than the little cone usually applied to such instruments.

Under these climatic conditions the Sheepshanks equatoreal was erected, and was found to have its vision greatly extended and improved. In Edinburgh, with *α Lyræ* nearer the zenith than in Teneriffe, Professor Smyth had never been able to see the companion (11 mag.); but at the Guajara station it was always visible, and the following smaller stars were also seen:—

C of	5 Aquilæ	14 mag. tabular.
D of	13 Lyræ	13 —
B of	128 Anseris	13 —
C of	185 Antinoi	12 —
B of	307 Aquilæ	13 —
B and C of	B Equulei	13 and 14 mag.

Definition was equally improved; such disks and rings were seen almost every night as had never been witnessed on any occasion in Edinburgh.

The increase of the black lines in the spectrum was remarkable as the sun's zenith distance increased: there was a growth of the red end of the spectrum; the definition of the lines improved, their numbers multiplied, and their thickness and blackness increased; with this feature, that certain lines remained constant, though amongst others that varied.

The horizon line of the sea was never seen; the sun invariably rose and set behind the line of the N.E. trade-wind cloud, and this had a zenith distance of 91° 11′. The zodiacal light was regularly observed, but not with confirmation of recent theories.

The improvement of astronomical vision was on the whole ascertained to be greater than had been generally expected from an elevation of 9000 feet, owing apparently to the lower strata of the atmosphere being contaminated with dry dusty particles of matter and having been in so far surmounted.

This dusty medium, however, does not terminate at 9000 feet; and was found to be so inveterate an interferer with the transparency of the air, that it was determined to try a higher station.

A second station (Alta Vista, 28° 16′·5 N., 16° 38′ W.) was therefore chosen with this view, and was occupied from August 21 to September 19: it was situated on the slopes of the Peak, at 10,710 feet above the sea; at a depth below the Peak of 1500 feet; was surrounded on three sides by steep-sided lava streams, and was the highest point possible to be reached without the expenditure of much time and money in removing obstructions. The following are notes of the circumstances that were found to prevail there.

Climate—Temperature 56° to 38°. *Dryness*—Depression of

Digitized by Google

the dew-point, maximum 46°, average 30°, minimum 18°; less therefore than at first station.*

Radiation of the sun greater than at the first station, and $= 128 + x$ or above graduation of instrument; with temperature $= 177° + x$, x being $= 10°$ or $20°$ or more, and this so early each day as 9^h A.M.

In this locality the great Pattinson equatoreal was erected.

For space-penetrating power stars of the 16th magnitude, as *b Equulei*, were easily seen.

For definition and separating power nothing in the way of distance, except it were less than a second, was deemed worthy of any attention.

The closest of the whole that was thus observed was B of *γ Andromedæ*, the components were seen thus night after night, *i. e.* there was a dark line between them, but the disks were somewhat compressed on that side. The last night it was so observed it was at an hour-angle of $4^h\ 35^m$.

Twenty double stars were observed at this station for definition and vision, and thirty-four for colour.

The sun's limb was frequently examined for red prominences both with the Sheepshanks telescope fitted up with Nasmyth's "bag," and with the Pattinson equatoreal supplied with other contrivances. Only once, however, was there any appearance of success.

The zodiacal light, twilight, and the spectrum, were again made subjects of observation, until the season broke up completely on the 14th of September, a month before the usual period; and the party abandoned the station on the 19th.

It was sufficiently demonstrated, however, that improvement of astronomical vision between 9000 and 10,700 feet is very sensible. But inasmuch as even that latter height is transcended by the upper regions of the "dust-haze," it would be highly desirable to try a higher station still. The culminating point of the Peak itself is not suitable, by reason of the hot and sulphurous vapours always escaping from the crater there; but on examining the upper part of the mountain distant from the crater, a site for a station was found at 11,700 feet, far removed from any immediate cause of the persecuting dust, and accessible to mules if a little money be spent in road-making amongst the lava blocks of the Malpays.

Such a station would be easy to occupy in summer, and would enable many important observations to be procured. It might not still be high enough for the red prominences; but it would be well to try it before going farther, as the next mountains which are higher, and at the same time practicable for observatory work, are the Andes on one side, and the Himalayas on the other,—both too far off to be compassed by a mere summer expedition.

* In the towns at the level of the sea the depression of the dew-point was only from 5° to 10°.

Digitized by Google

At Liverpool, the principal general astronomical work has been the observation of the new planets, when first discovered. Mr. Hartnup is more than ever employed in the special business of his institution. In his last report, he states that a greater interest is now taken in what he is doing; and that from the mass of evidence, which the records of the Observatory now furnish, he is able to make the utility of the institution very clear to naval visitors. Under the direction of the Board of Trade, azimuth compasses have been furnished gratuitously to a considerable number of ships, on condition of the commanders returning a record of the observations made for the correction of the steering compasses. Arrangements are now made for testing the barometers and thermometers used at sea,—and not before it was wanted, seeing that Mr. Hartnup finds an error of from half an inch to an inch to be no uncommon matter in the reading of the barometers used in the merchant service. Some papers by Mr. Hartnup, printed in the *Transactions of the Historic Society of Lancashire and Cheshire*, and treating of the corrections of chronometers and meteorological instruments, show both Mr. Hartnup's activity in his most peculiar business, and the success of his efforts to excite attention to the subject.

We may at length congratulate the Madras Observatory on the prospect of being furnished, by the liberality of the Court of Directors, with a new meridional circle, which has been already ordered of Mr. Simms, and which, it is hoped, will materially increase the efficiency of the Observatory, and enable it to take up the minor planets, for which class of observation it seems particularly qualified by geographical position. Awaiting the arrival of the new instrument, nothing of importance in the way of meridional observation has been attempted with the old ones, now nearly worn out. Capt. Jacob resumed charge of the Observatory on 29th December, 1855, and recommenced observations with the equatoreal, which had been nearly suspended during his absence. The work done during the past year has been chiefly measures of a few of the principal double stars, among which *α Centauri* holds a conspicuous place, the components having now an angular motion of nearly 15° per annum; also physical observations of *Mars* and *Saturn*, and measures of *Saturn's* ring and satellities. We regret to learn that Capt. Jacob's health is again failing, and that there is little hope of his being able to remain much longer at his post.

At Redhill Mr. Carrington brought the observations of position for his circumpolar catalogue to a conclusion on the 20th of September last, and the reductions to apparent place were not more than ten days in arrear of the telescope. On summing up, it was found that the total number of observations for the catalogue amounted to 13,110. The first two sections were finally arranged and cleared of the ordinary errors of recording in the

Digitized by Google

month of June previously, and now require only a last critical examination. For the third and last section the corrections to mean place are computed, and are being worked the second time previously to application. This section will, accordingly, be also finished in about six or seven weeks.

A very valuable work has, during the year, emanated from the Vienna Observatory, the reduction by M. Oeltzen of the circumpolar star observations of Prof. Schwerd of Speyer, and has been welcomed as a very acceptable arrival at Redhill. That catalogue affords well-determined positions for the year 1828 of about 690 of the brighter stars included in Mr. Carrington's region. It was obviously indispensable that the positions of Schwerd should be brought up to 1855, and compared with those determined at Redhill, previously to the publication of the latter. Concluded mean places were therefore formed from the single observations given by M. Oeltzen, and the whole brought up to the year 1855, with Peters' constants of precession, and the formulæ of Bohnenberger, given by Bessel in his *Tab. Regiom.* This process, which was one of no great labour, is also finished, and the partial comparison hitherto instituted has shown a very satisfactory degree of accordance between the two authorities. So soon as the comparison can be made general, reference will be made to M. Oeltzen respecting the errors detected in Schwerd's places, many of which depend on single determinations. By this means the modern positions of the more important stars will be accompanied by pretty close approximations to their proper motions.

There remain, then, at the date of this Report, about six weeks' work for the completion of ordinary reductions, the arrangement of the whole, the dressing down the estimated magnitudes to the scale of our standard observers, and the reworking of the maps. It is a little difficult to estimate the precise time which will be necessary; but it will probably not much exceed three months.

The solar spots have been observed and treated precisely as during the past two years; but the discussion of the positions observed is still postponed for the present.

The past year also witnessed the inauguration of another first-class observatory in the United States, at Albany, the capital of the State of New York.

This institution is due to the munificence and public spirit of a few individuals in that city, especially to that of a lady, Mrs. Dudley, by whose name it is to be called.

This lady, who henceforth takes a place among the chief benefactors to astronomy, has presented the munificent sum of $64,500, (exceeding 13,000*l.* of our money); of which $14,500 are to be appropriated to the acquisition of an heliometer of the largest size; and the remaining $50,000 are to form part of the maintenance fund of the observatory.

The heliometer will be made by Mr. Spencer, an American

Digitized by Google

artist, whose reputation as a maker of microscopes has been long established.

The other principal instruments are to be a transit and a meridian circle, also of first-class dimensions. The circle, by Pistor and Martins of Berlin, has, we believe, already arrived in the States.

The American, or, as it is now called, the Chronographic system of registration, is to be extensively applied, and the apparatus for this purpose is said to be of great excellence.

The direction of the new observatory has been offered to our associate, Dr. Gould of Boston, in whose hands its magnificent appliances, we are sure, will not be allowed to remain idle.

During the past twelvemonth the minor-planet group has received an accession of four new members, making the present number of these small bodies *forty-two*.

Lætitia was discovered by M. Chacornac, at the Imperial Observatory, Paris, on the 8th of February.

Harmonia, by Mr. Herman Goldschmidt, on the evening of March 31st.

Daphne, by the same observer, on the 22d of May. The elements of this planet are hardly determinable from the few observations that were procured, the opposition being far passed at the time of discovery. It is not unlikely that considerable difficulty may be experienced in detecting the planet again, though the ecliptical star-maps now in the possession of astronomers will afford a ready means of watching the minute stars in the vicinity where it may be expected to show itself.

The fourth planet, named *Isis* on the suggestion of our President, was found at the Radcliffe Observatory, Oxford, by Mr. Norman Pogson, on the 23d of May. It should not be forgotten, in forming an estimate of Mr. Pogson's zeal and diligence as an observer, that it is only during his leisure hours, after the regular duties at the Observatory are ended, that he is able to pursue the search for new planets by star-mapping and systematic examination of the heavens in the region near the ecliptic.

Vague notices have appeared in the newspapers with reference to a comet seen on the coast of Peru, in August last, and another visible in the north-west sky at Panama early in January; but no observations of either have yet been published. There is some probability that the comet of August was remarked on the 7th of the month, at Beeston Observatory, near Nottingham, according to a note issued by Mr. Lowe: the object, supposed to have been a comet, was situate in the constellation *Virgo*. It is much to be desired that, if any one has been fortunate enough to secure positions of either comet, however rough they may be, he will make them known.

The recent occultation of *Jupiter*, and the exhibition of the private forces of astronomy which it has drawn out, gives the

Digitized by Google

Council the opportunity of suggesting to private observers one or two points to which their attention may be usefully directed. Private individuals, possessed of fine instruments, need not be content with the verification of known facts and the observation of predicted phenomena. In astronomical observation, as in other things, there are those who are diffident of their own power to originate, and who content themselves with showing, in matters which they are not afraid to touch, all the industry and all the sagacity which would have given them the best chance of success in actual extension of our knowledge.

In the first place, there is comet-seeking. It would give the Council much pleasure to know that several of the unprofessional members of the Society made a practice of watching selected portions of the heavens for the passage of these bodies, and of learning readily to distinguish between them and the nebulæ. Our German friends have hitherto—and all praise to them for it—received most of the King of Denmark's medals, and this country has taken comparatively little part in thus watching the skies. May we hope to see the professional observer occasionally fed with a comet by our private searchers? The pursuit is peculiarly one in which a telescope may be usefully taken up for an hour or two and put by again.

Photometry again still offers very much for research: but to pass on to another subject, we may remind our members that no one has at present produced on our table a photographic image of a fixed star. A good or even a moderate photographic image of a group such as the Pleiades would be something we have not yet had the pleasure of seeing; and a fair approach to getting an instantaneous image of a group of faint points might lead the way to results of great importance. It may be long, or it may not be long, before we have to add a column of actinic magnitudes to our catalogues, and replace the human retina by a surface still more sensitive to luminous impressions.

In the sixteenth volume of the *Notices* of this Society (page 178), is an abstract of a paper by Professor Plana, on some corrections necessary to be applied to some of the terms of the fourth order in the analytical expression for the secular acceleration of the mean motion of the moon, in which he appears to recognise as confirmed a correction in the coefficient of m^4 previously detected by Mr. Adams.

In June 1856 he read before the Academy of Sciences at Turin another paper, of which we propose to give a short account, in which he appears to have considerably modified his views with regard to these corrections, and, with the exception of the coefficient of m^4, he considers as confirmed all the coefficients to the fourth order, found in the expression for the secular acceleration as given in the first volume of the *Théorie de la Lune*. Several terms of the fifth, sixth, and seventh orders he points out as necessary to be added; but the chief circumstance to be remarked is that the

Digitized by Google

correction, which he now states to be necessary to the coefficient of m^4, is not that found by Mr. Adams, but has a totally different value. For the sake of clearness we will give all the values which have been attributed to this coefficient:—

That given in the *Théorie* is	$-\frac{2187}{128}$
Adams's coefficient (confirmed by Plana in his previous memoir) is	$-\frac{3771}{64}$
Plana's new coefficient is	$-\frac{351}{64}$

Throughout the whole of the memoir under review M. Plana makes no allusion to the researches of Mr. Adams, except in a note, in which he remarks, that if two terms, which it is absolutely necessary to keep separate, and one of which cannot enter into the expression for the secular acceleration, be added together, the coefficient found by Mr. Adams will be derived. This want of reference to preceding researches (for his own previous memoir is barely mentioned with reference to the typographical error discovered in Vol. I. of the *Théorie*), produces some obscurity in the present memoir, and we can only assume that he wishes the investigation now before us to be substituted for the one previously given, in which Mr. Adams' correction appeared confirmed.

All that can be done then, in a brief account of this elaborate paper, is to state the chief results which are now apparently considered to be definitely settled, and to quote a few passages giving the views of M. Plana, and his reasons for their adoption.

It has been stated that the coefficient of m^4 now arrived at is, $-\frac{351}{64}m^4$. Adopting this term, substituting the corrections indicated in the terms of higher orders, and calculating all the numerical coefficients anew, M. Plana finds that the principal term in the acceleration (that is, the term to be multiplied into the square of the number of centuries) is 11″·51157. This value he finds to satisfy very well several well-known ancient eclipses, amongst which he specifies that observed at Babylon in the year 720 B.C., and that of Theon at Alexandria in the year 364 B.C.

The following passage expresses, perhaps, more clearly than any other in the memoir, his views with regard to the necessity of rejecting one of the terms which together make up Adams's coefficient of m^4.

"In considering separately the part of the secular equation of the mean motion of the moon, which, by a particular combination, gives rise, by virtue of integrations, to periodical terms multiplied into the differential coefficient $\frac{d\iota'}{d\gamma}$ of the secular variation of the excentricity of the earth's orbit, we should obtain a quantity, which by its form appears as if it must be an integral part of this same equation. But, in examining more closely the origin of this part, I have found out that its addition to this primitive part is inadmis-

Digitized by Google

sible." He then gives the complete expression containing all the terms which would be thus improperly introduced, the principal of which is $-\frac{855}{16}m^4$, and continues: "In calculating the following terms, we should reduce the coefficient of the secular equation to such a degree of minuteness that it would be incompatible with observations both ancient and modern. At the same time, independently of this indirect consideration, it can be demonstrated, that the complete suppression of this part is required by the method even of the successive approximations, on which is founded the whole of the theory which furnishes the coefficients of the lunar inequalities."

In a following section of the paper he proceeds to demonstrate the proposition which he thus lays down, but the reasoning is of too analytical and abstruse a character to be introduced here. Probably enough has been given to show M. Plana's opinion of the present state of the controversy respecting the values of the coefficients of the terms of the secular equation of the mean motion of the moon, and also to show what corrections must be made to the results of the *Théorie* and of his memoir preceding the one under consideration, to represent those which he now substitutes for them.

Amongst the astronomical works of which it is incumbent on us to take notice, probably the most remarkable are the two first volumes of the *Annales* of the Paris Observatory, published rather more than a twelvemonth ago by Le Verrier. Though published at the end of 1855, but few copies have found their way into this country till very recently, and this may account for the tardiness of the notice which we now propose of the work.

It is printed in two large quarto volumes, containing about 400 pages each, and contains certainly the most perfect and the most concise system of modern theoretical and practical astronomy extant, and a very brief statement of its contents will convince any one tolerably conversant with astronomical operations that it must ultimately come into general use amongst astronomers, and will probably occupy that place which up to this time has been retained by the *Tabulæ Regiomontanæ* of Bessel.

The three most important divisions of the book are, 1st, the introduction; 2d, the application of pure mathematics to the most important of the processes of spherical and physical astronomy; and 3d, the recalculation of the greater number of the tables of the *Tabulæ Regiomontanæ*, founded on a new discussion of the places of Maskelyne's 36 fundamental stars, by help of the best modern determinations of the constants of reduction.

To begin with the introduction. In this, the chief object of Le Verrier is to show what organisation and what development must be given to the Paris Observatory to enable it to take for the future an honourable part in the various classes of observations which the present extension of the science of astronomy has intro-

Digitized by Google

duced, and in the cultivation of the other sciences to which it has become so intimately allied. In doing this he traces historically the rise and progress of each branch of observation, the various improvements which at various epochs it has received, and the state to which it has arrived at the present time, both with regard to instrumental means and to improvements in methods of observing. And one remarkable fact is elicited which it is worth while to attend to, that, since the middle of the last century, when Bradley commenced his admirable series of observations, the observatory of Greenwich has been uniformly improving both the instruments and the methods of observation, and has with undeviating regularity pursued those classes of observations which are necessary for establishing the fundamentals of astronomy, while the Paris Observatory has never, since the time of the Cassinis, taken any prominent part in the improvement or development of the science. Undoubtedly the object of the author is to place the contrast between the remissness of the French national observatory and the activity of foreign establishments in as strong a light as possible, for the purpose of inducing the French Government to provide on an adequate scale for the future development of the institution, according to the enlarged and philosophical views which he has so admirably laid down. Still, it is gratifying to find that in the proposed organisation of the observatory, reference is almost always made to Greenwich, as presenting the best existing model for carrying out the proposed plans of extension and reform.

He sums up briefly at the end of the introduction, the chief articles of the reform which will be necessary in the Paris Observatory to put it in a condition to compete successfully with Greenwich and other great European observatories, and to play the part which he thinks absolutely necessary in the existing state of the science.

His chief recommendations are the following:—To repair the existing instruments and to provide others which are necessary, including a large transit-circle and a galvanic apparatus for recording transits and for distributing time. To establish the great equatoreal which is already in course of preparation. To organise a computing-staff for the reduction of observations, and especially to provide for the reduction of all observations made since 1847. To pursue, in common with the Marine administration, the means necessary for rating chronometers both at Paris and at the ports, for extensive distribution of precise time, and for new and accurate determinations of longitudes. To make provision for the regular study of the great questions in physical astronomy. To organise a system of meteorological observations and research. And, lastly, to provide accommodations for the observers, and the requisite funds for carrying out all the specified objects.

The book itself contains an admirable collection of almost all the formulæ which are necessary in the whole range of astronomy, together with many elaborate tables belonging to the different

Digitized by Google

divisions of the science. The first part, included in the introduction, is devoted to such portions of pure mathematics as are most frequently required. Setting out with circular functions and plane trigonometry, he discusses in succession the doctrine of spherical triangles, series, interpolations, method of quadratures, the resolution of equations of condition according to the method of least squares, &c. Proceeding then to spherical astronomy, he treats of geocentric and heliocentric co-ordinates and the transformation from one set to the other, the theory of the planetary and cometary orbits (adding a table for parabolic motion), and other similar subjects. He then proceeds to physical astronomy, and explains fully the application of the variation of parameters to the orbits of the disturbed planets. In another chapter he discusses the development of the disturbing function, giving tables for particular planets, and treating at considerable length of the great inequality of *Pallas*. The remaining subjects of this portion of the work, are, the discussion of perturbations of the second order with regard to the masses, the doctrine of the secular inequalities of the planets, and the definitive elements of the eight principal planets. This part is concluded with a very elaborate discussion of precession and nutation.

The third division of the work is devoted to the positions of the fundamental stars; and it is this portion which will be perhaps best known and most useful in the ordinary processes of practical astronomy. By means of the formulæ, given and discussed with admirable precision at the commencement, including those for reducing the position of a star from one epoch to any other, he gives a table of the mean right ascensions and mean declinations of Maskelyne's 36 fundamental stars for the epochs 1755 and 1845, the former resulting from his rigorous and independent reduction of Bradley's observations, and the latter from a severe discussion of the modern Greenwich observations since 1836.

He then gives in detail the successive steps of his reductions of Bradley's observations, and his discussion of the modern Greenwich observations, and concludes the work with a series of tables similar to those of the *Tabulæ Regiomontanæ*, including all the elements of reduction necessary for finding the apparent places of the 36 fundamental stars for any day between the year 1750 and the year 1900.

The preceding account may serve to awaken the interest of astronomers, and to induce them to study its contents. It is equally well adapted for the uses of the university or of the observatory; and, while it is invaluable to the practical astronomer, parts of it might with great advantage be introduced into our schools and colleges, where the higher branches of astronomy are taught; and the author would be doing a serviceable work if he would provide for its publication in an octavo form, with such retrenchments as would enable it to fulfil the purpose of a handbook of astronomy.

Digitized by Google

The subject of Oriental astronomy is one which demands peculiar literary qualifications, and very few are able to advance or correct existing European knowledge of it. A very interesting addition to this part of the subject has been made by Mr. Wm. H. Morley, who has devoted much time, research, and money, and a familiar knowledge of the Oriental tongues, to the illustration of the astrolabe, the great instrument of the East. Under a title which professes no more than to describe an astrolabe made for the Sultan Husain Sufawi, and preserved in the British Museum, he has gone deeply into the details of this instrument, its construction, use, and history, the knowledge of it in Europe, and the varieties of it known to exist. The plates are taken by the anastatic process from the instrument itself, which is thus copied to the life. Advantage has been taken of the size thus rendered necessary to produce a gorgeous specimen of typography. Ample citations are given from original writers in Persian and Arabic, and the work is thus as complete a monograph as has ever been given to the world. That very few can fully avail themselves of Mr. Morley's labours does not lessen his title to our gratitude; the future historians of astronomy will not deserve the name if they do not avail themselves of the means of accuracy which he has placed within their reach.

The Society will be glad to be informed that the printing of the new Lunar Tables by Professor Hansen is proceeding rapidly, at the expense of the British Government, and under the immediate care of the Astronomer Royal. Professor Hansen came to Greenwich to superintend the commencement of the work, and himself revised the elaborate introduction, which contains a careful exposition of the formulæ and tables. The work, when completed, will form a large quarto volume, nearly as thick as a volume of the *Greenwich Observations*. It is understood that Professor Hansen will shortly publish the Theory on which the Tables are based.

While speaking of the works of Professor Hansen, we would also draw attention to a short paper by him recently inserted in our *Monthly Notices*. In Cicero's book *De Republicâ* is an obscure quotation from Ennius relating to an ancient eclipse which took place in his time. Professor Hansen has succeeded in identifying this eclipse with the date, and thereby fixing the technical chronology of the Roman months at this remote period of history.

We cannot pass without a word of congratulation a notice which has recently appeared of the present labours of Professor Argelander. Our experienced associate is still pursuing his steady course of approximating to a more and more perfect knowledge of the contents of our European skies; and in this projected atlas of the northern hemisphere, which he reckons on completing by the year 1862, and in which he designs to comprise every star in the first 9 magnitudes, we see another step in advance worthy of his

Digitized by Google

antecedents. The meridian observer will thus be furnished with an ample working catalogue, and the chart-maker with a basis for maps of the greatest elaboration. It may appear rather strange at first, that for several years the principal work of the magnificent establishment at Bonn should be performed with a little telescope of 34 lines aperture, and that no refinement of observation or reduction should be aimed at beyond what is necessary for chart-positions; but knowing, as we do, the requirement which exists of extended knowledge of the region to the north of the much-cultivated ecliptic, we applaud Professor Argelander's resolution in renouncing for a time work of more pretension for this proposed survey.

In the forty-fourth volume of the *Astronomische Nachrichten*, Nos. 1040–2, is an elaborate paper by Mr. Marth, of the Durham Observatory, entitled "Researches on Satellites," to which we are desirous of directing the attention of the Society.

The writer proposes in this and succeeding memoirs to investigate the motions of the satellites of *Saturn*, *Uranus*, and *Neptune;* but, in the present instance, he has confined himself to the preliminary mathematical investigations which are necessary. In the first portion of the paper he deduces the formula by which the apparent positions of the satellites referred to the planet, either by means of angular distance and position-angle, or by differences of right ascension and declination, may be calculated from given elements and given places of the planet; and by which likewise the equations of condition may be found which exist between variations of the positions and corresponding variations of the elements. He then shows how to determine the approximate elliptic elements of the orbits which are to be used in the calculations; and he, lastly, takes into account the disturbances introduced by the action of the sun and other bodies.

He promises, in succeeding memoirs, to give the results of his numerical researches on the orbits of the satellites of *Saturn*, *Uranus*, and *Neptune*.

Papers read before the Society from February 1856 *to February* 1857.

1856.

Mar. 14. On the Rings of *Saturn*. Signor Secchi.
Occultations of Stars by *Saturn*. M. Winnecke.
On *Saturn's* Rings. Mr. De La Rue.
Elements of *Leda*. Mr. Pape.
Description of an Observatory. Mr. Brodie.
Observations of Solar Spots. Capt. Shea.
On the Meteor of January 7, 1856. Dr. Mann.

Digitized by Google

Discovery of a New Planet. M. Chacornac.
On the Rings of *Saturn*. Capt. Jacob.
Observations of Minor Planets at Greenwich. The Astronomer Royal.
On certain Anomalies in the Orbit of *α Centauri* and on the Rings of *Saturn*. Capt. Jacob.
Observations of Minor Planets. The Astronomer Royal.
On the Solar Spots. Capt. Shea.
Plan proposé pour l'Etude du Magnétisme Terrestre. M. Laugier.

April 11. On the Outer Ring of *Saturn*. Mr. Watson.
On the Appulse of a Star to *Saturn's* Ring. Rev. W. R. Dawes.
Occultation of *Antares* by the Moon. Mr. Breen.
Do. do. Rev. W. R. Dawes.
Do. of Stars by the Moon. Capt. Shadwell.
On the Dimensions of the Bright Ring of *Saturn*. Dr. Kaiser.
On the Value of the Diameters of *Mercury*, *Venus*, &c. Rev. R. Main.
On the Conjunction of *Jupiter* and *Saturn*, B.C. 7. Rev. C. Pritchard.
Description of Observatory at the Collegio Romano. Signor Secchi.
Experiments on Solar Radiation. Prof. C. P. Smyth.
Occultation of *Antares* by the Moon. Mr. Whitbread.

May 6. Observations of Minor Planets. The Astronomer Royal.
Catalogue of Double Stars. Mr. E. B. Powell.
Measures of *Saturn's* Rings. Mr. De La Rue.
Note on Variable Stars. Mr. Wackerbarth.
Description of an Observatory at Tulse Hill. Mr. Huggins.

June 13. Observations of Minor Planets. The Astronomer Royal.
Do. do. Cambridge. Mr. Breen.
Results derived from an Examination of certain Places of the Five principal Planets on Four Egyptian Tablets. Mr. Ellis.
Observations of *Isis*. Mr. Pogson.

July 11. Occultations. Capt. Shadwell.
Do. Lieut. Dayman.
Telescopic Appearance of *Mars*. Mr. Brodie.
On the Period and Changes of *α Herculis*. Mr. Baxendell.
On the Variability of 13 *Lyræ*. Mr. Baxendell.
Occultation of *Antares*. Mr. Burr.

Nov. 14. Longitudes derived from Solar Eclipse, Nov. 19, 1854. Rev. R. Main.
Results of Observations of Small Planets. Mr. Airy.
Observations of Klinkerfues' Comet. Mr. Maclear.
Geocentric R.A. and N.P.D. of Encke's Comet, &c. Mr. Maclear.
Micrometrical Measures of *Antares*. Mr. Maclear.

Digitized by Google

Occultation of *Jupiter* by the Moon. Mr. Chalmers.
Corrections to be applied to Sextant Observations. Mr. W. H. Simms.
On Finding a Meridian. Mr. Hart.
Note accompanying Drawings of *Mars*. Capt. Jacob.
Occultation of *Jupiter* by the Moon, Nov. 8, 1856. Lord Wrottesley.
Telescopic Appearance of *Saturn*. Rev. W. R. Dawes.
Lunar Occultation of *Jupiter's* Fourth Satellite. Rev. W. R. Dawes.
Occultation of *Jupiter* by the Moon, Nov. 8. Mr. De La Rue.
Observations of *Jupiter*, Oct. 1856. Mr. De La Rue.
Formulæ for the Determination of Latitude by observed Transits of Stars near Prime Vertical. Mr. W. H. Simms.
Occultation of *Jupiter*, Nov. 8. Mr. Huggins.
Observations of *Antares*. Mr. Hippisley.
On the Projection of Stars on Disk of Moon. Capt. Jacob.
On the Division of the Outward Ring of *Saturn*. Mr. Hartnup.
Results of Observations of Small Planets. Mr. Airy.
Magnitudes of Thirty-six Minor Planets. Mr. Pogson.
Occultation of *Jupiter*, Nov. 8. Mr. Goddard.
Annular Eclipse, Sept. 18, 1857, Calculated Position of Central and Limiting Line. Lieut. Tennant.
Occultation of *Jupiter*, Nov. 8. Mr. Grove.
Do. do. do. Mr. Burr.

Dec. 8. On a Mode of Constructing Tubes for Telescopes. Mr. Brodie.
Note accompanying Drawings of *Jupiter*, &c. Mr. Huggins.
Do. do. do. Mr. Barclay.
On Variable Stars. Mr. Pogson.
Results of Observations of Minor Planets. Mr. Airy.
Proposed Method of relieving Weight of an Azimuth, &c. Lieut. Tennant.

1857.

Jan. 9. On the Projection of Stars on the Moon. Mr. Hippisley.
Occultations observed at Highbury. Mr. Burr.
Occultation of *Jupiter*, Jan. 2, 1857. Mr. Burr.
Do. do. do. Mr. Huggins.
Do. do. do. Mr. Lowe.
Do. do. do. Dr. Mann.
Do. do. do. Mr. Watson.
Do. do. do. Rev. S. W. Webb.
Do. do. do. Mr. Jeans.
Do. do. do. Mr. Perigal.
Do. do. do. Rev. W. R. Dawes.
Do. do. do. Mr. Brodie.

Digitized by Google

Occultation of *Jupiter*. Jan. 2, 1857. Dr. Lee.
Do. do. do. Rev. C. Lowndes.
Do. do. do. Dr. Brereton.
Do. do. do. Dr. Turnbull.
Do. do. do. Mr. Dell.
Do. do. do. Lord Wrottesley.
Do. do. do. Mr. Peto.
Various Observations. Mr. Lassell.
Notice of Solar Observations. Mr. Carrington.
On the Horary Variation of Meteors. Mr. Bompas.
Occultation of *Jupiter*, Jan. 2. Mr. Airy.
Do. do. Mr. Hodgson.
Projection of *Jupiter's* Satellite on the Disk of the Planet. Mr. Hodgson.
Occultation of *Jupiter*, Jan. 2. Dr. Robinson.
Do. do. Mr. Worthington.
Do. do. Mr. Pogson.
Do. do. Mr. Hartnup.
Do. do. Mr. Jee.
Do. do. Rev. J. Slatter.

List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.

Her Majesty's Government.
Royal Society of London.
Royal Society of Edinburgh.
Royal Geographical Society.
Royal Asiatic Society.
Royal Institution.
Royal Irish Academy.
Royal Dublin Society.
Geological Society.
Linnean Society.
Photographic Society.
Zoological Society.
Society of Arts.
Philosophical Society, Liverpool.
Philosophical Society, Manchester.
Historic Society of Lancashire.
British Association.
Institute of Actuaries.
Hon. East India Company.
The Lords Commissioners of the Admiralty.
The Commissioners of the Exhibition of 1851.
The Registrar-General.
The Superintendent of the Nautical Almanac.
The Radcliffe Trustees.
University College, London.

Digitized by Google

Royal Observatory, Edinburgh.
L'Académie Impériale des Sciences de l'Institut de France.
L'Observatoire Impérial de Paris.
Le Bureau des Longitudes.
Le Dépôt Général de la Marine.
L'Académie des Sciences de Dijon.
The Society at Cherbourg.
Imperial Academy of Vienna.
Imperial Observatory of Vienna.
Royal Academy of Munich.
Royal Observatory of Munich.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Society of Göttingen.
The Society of Wurzburg.
The Society of Danzig.
The Society of Geneva.
The Society of Naples.
Royal Academy of Sciences, Madrid.
Royal Observatory, Königsburg.
Royal Observatory, Palermo.
American Government.
American Academy of Sciences.
American Philosophical Society.
Franklin Institute.
Smithsonian Institution.
Observatory at Harvard College.
Observatory at George Town College.
Observatory at San Fernando.
Philosophical Society of Victoria.
The Editor of the Athenæum Journal.
The Editor of the Literary Gazette.
The Editor of the Critic.
The Editor of the Civil Engineers and Architect's Journal.

G. B. Airy, Esq.
C. Babbage, Esq.
Prof. A. D. Bache.
M. Biot.
Miss Baily.
Commander Bate.
W. H. Buxton, Esq.
Lady Bellew.
T. W. Burr, Esq.
M. C. Bruhns.
Dr. Bremiker.
R. C. Carrington, Esq.
E. J. Cooper, Esq.
Prof. A. Colla.
Warren De La Rue, Esq.
J. C. Durnford, Esq.
M. H. D'Arrest.
Dr. Donati.
Prof. Encke.
Rev. J. Ebden.
Prof. A. Gautier.
Dr. B. A. Gould.
Lieut. J. M. Gilliss.
M. Grunert.
J. Herapath, Esq.
Rowland Hill, Esq.
J. R. Hind, Esq.
M. K. Hornstein.

Digitized by Google

Prof. Heis.
A. Harpur, Esq.
M. A. Hersch.
H. Hennessey, Esq.
Prof. Hansen.
Lieut. Hardy.
W. H. R. Jessop, Esq.
M. K. Von Littrow.
L'Abbé Moigno.
W. H. Mosley, Esq.
Dr. Mann.
Sir W. Keith Murray, Bt.
His Grace the Duke of Northumberland.
M. J. C. Oudemans.
H. Perigal, jun., Esq.
Dr. Peters.
M. Plantamour.
Dr. A. J. Pick.
M. Plana.
Prof. Ragona.
Geo. Rennie, Esq.
Admiral Sir John Ross.
Capt. Shadwell.
Sir James South.
Sig. Secchi.
M. K. Schroeder.
J. M. Share, Esq.
R. Taylor, Esq.
Capt. H. Toynbee.
M. F. Winnecke.
W. S. B. Woolhouse, Esq.
Dr. R. Wolf.

Address delivered by the President, M. J. Johnson, Esq., on presenting the Medal of the Society to M. Schwabe:—

Gentlemen,—The order of our proceedings has now brought us to the presentation of the medal which, as you have heard, the Council has awarded to M. Schwabe, for his discovery of the periodicity of the solar spots.

M. Heinrich Schwabe is a gentleman resident in, and I believe a native of, Dessau, the capital of the Duchy of Anhalt Dessau, who, having no professional duties, has devoted much time and attention to scientific studies, and has attained considerable reputation in other departments of knowledge than that in which he is known to this Society. Among other accomplishments, I am informed that M. Schwabe is an excellent botanist, and has composed, though, I believe, not published, a flora of the neighbourhood of Dessau.

It was in 1826 that he entered upon those researches which are now to engage our attention. I am not aware of the motive that induced him—whether any particular views had suggested themselves to his own mind—or whether it was a general desire of investigating, more thoroughly than his predecessors had done, the laws of a remarkable phenomenon, which it had long been the fashion to neglect. He could hardly have anticipated the kind of result at which he has arrived; at the same time we cannot imagine a course of proceeding better calculated for its detection, even if his mind had been prepared for it, than that which he has pursued from the very commencement of his career. Assuredly if he entertained such an idea, it was not borrowed from the

Digitized by Google

authorities of the last century, to whom the solar spots were objects of more attention than they have been of late years.

"Nulla constanti temporum lege apparent aut evanescunt," says Keill in 1739.—*Introduct. ad Physic. Astronom.* p. 253.

"Il est manifest par ce que nous venons de rapporter qu'il n'y a point de règle certaine de leur formation, ni de leur nombre et de leur figure," says Cassini II. in 1740.—*Elém. d'Astron.* vol. i. p. 82.

"Il semble qu'elles ne suivent aucune loi dans leur apparitions," says Le Monnier in 1746.—*Instit. Astron.* p. 83.

"Solar spots observe no regularity in their shape, magnitude, number, or in the time of their appearance or continuance," says Long in 1764.—*Astron.* vol. ii. p. 472.

"Les apparitions des tâches du soleil n'ont rien de regulier," says Lalande in 1771.—*Astron.* vol. iii. § 3131, 2d edit.

And Delambre's opinion may be inferred from a well-known passage in the third volume of his *Astronomy* (p. 20), published in 1814, where treating of the solar spots he says, "Il est vrai qu'elles sont plus curieuses que vraiment utiles."

I cite these passages to show, whatever might have been Schwabe's own view of the matter, that a periodicity of the spots was not a current idea at the time he entered upon the subject, and therefore that he has not merely developed a law for which men's minds were prepared, but that he has been, to all intents and purposes, the discoverer of it. The first suggestion I have met with (and that a very vague one) of anything of the kind occurs in the article "Sonnenflecken," in Gehler's *Physicalisches Wörterbuch*, written by the elder Littrow, and published in 1836, long after Schwabe had been at work.

It was in 1826, as I have said, that Schwabe began his observations, but I am not aware of any published results before those in No. 350 of the *Astronomische Nachrichten*, which appeared in April 1838. Here he gives a summary of twelve years' labour, and though at this time he must have begun to foresee the issue, for the indications of periodicity are plain, he makes no remark, nor does the memoir appear to have attracted the attention of astronomers.

From this time commence his annual contributions to the *Astronomische Nachrichten;* but it was not till the end of 1843, when he had passed through two periods of maximum and minimum, that he very modestly remarks that his observations heretofore had given indications of periodicity which that year's result tended to confirm. Still the subject attracted little attention. As far as I can discover, the only person who had taken it up was Julius Schmidt, the present indefatigable Director of the Observatory at Olmütz, then residing near Hamburg. But the philosopher of Dessau was not disconcerted; he went on accumulating fresh proofs of his great discovery, which, when announced in 1851, by Alexander Von Humboldt in the third volume of his immortal *Cosmos*, came upon the world with all the freshness of

Digitized by Google

novelty, though in reality the secret had been revealed eight years before.

Now, gentlemen, what were the means and processes by which Schwabe arrived at his results? These he tells us in No. 350 of the *Astronomische Nachrichten*, to which I have already referred.

His instruments are two telescopes, by Frauenhofer, one a $3\frac{1}{2}$, the other a 6-foot, with powers of 45, 64, and 96, the last only used in extreme cases. The apertures of his object-glasses were generally reduced to $1\frac{1}{4}$-inch and $2\frac{1}{4}$-inches, an arrangement by means of which he obtained the double advantage of being able to protect his coloured glasses, and to use lighter tints than would have been otherwise practicable. He particularly recommends glasses of a certain blue tint which he obtained from Munich.

His observatory, I am informed by Mr. Carrington, is a small apartment on the top of his dwelling-house.

His method of observation is as simple as his apparatus, and he has felt throughout his inquiries the force of the precept, as necessary in cases of this kind as in that which the poet had especially in view,—

> "Servetur ad imum,
> Qualis ab incepto processerit, et sibi constet;"

from first to last he has never altered his system of classification and registration.

His plan is to note by a number each spot in the order of its appearance, carrying on his notation from the first to the last spot in each year. He reckons an isolated spot, or a cluster of spots where there is no visible separation between their penumbræ, as one group. "Hence," he observes, "the number of *spots* will depend in a great measure on the excellence of the telescope; and it often happens that clusters of many hundred, nay of many thousand spots, will be designated by one number only, just as a single isolated spot will be. So great, however, is the sun's tendency to present his spots in the form of clusters, that other observers will, in the course of a year, assuredly not find any great difference between their numbers and mine." But he particularly impresses on his readers that he attaches importance not so much on the absolute number of the groups, as on the ratio which obtains between them in different years.

The result of his investigations, as you are aware, has been to establish with a degree of probability almost amounting to certainty, that the solar spots pass through the phases of maximum and minimum frequency, and *vice versâ*, in a period not very different from ten years.

The exact period Schwabe does not pretend to have determined. That it is liable to perturbation is evident. During twenty-seven years of the series the results were extremely regular; during the last three years they have shown symptoms of disturbance. The epoch of minimum, which, consistently with earlier indications, should have happened in 1853, did not occur until 1856.

Digitized by Google

Such is the brief history of thirty years' labour, which, had I wished, I could hardly have prolonged: in fact, descriptively, there is little more to say about it.

You will have observed that the instruments were of the simplest kind. And though the arrangements in the first instance, as must be the case in all physical researches, called for the exercise of thought and intelligence—qualities the possession of which, in a very high degree, no one who reads M. Schwabe's papers in the *Astronomische Nachrichten* will deny him—these arrangements once made, the observations were of a description requiring for their prosecution more experience than skill.

It was not then for them, or for any special difficulty attending the research, that your Council has thought fit to confer on M. Schwabe this highest tribute of the Society's applause. What they wish most emphatically to express is their admiration of the indomitable zeal and untiring energy which he has displayed in bringing that research to a successful issue.

Twelve years, as I have said, he spent to satisfy himself—six more years to satisfy, and still thirteen more to convince, mankind. For thirty years never has the sun exhibited his disk above the horizon of Dessau without being confronted by Schwabe's imperturbable telescope, and that appears to have happened on an average about 300 days a-year. So, supposing that he observed but once a-day, he has made 9000 observations, in the course of which he discovered about 4700 groups. This is, I believe, an instance of devoted persistence (if the word were not equivocal, I should say, pertinacity) unsurpassed in the annals of astronomy. The energy of one man has revealed a phenomenon that had eluded even the suspicion of astronomers for 200 years!

Let us hope that the example will not be lost. Men are apt to speak of astronomy as an exhausted science, meaning that all that can be known is known. No doubt being the most perfect, it is in one sense the most exhausted science. But the astronomer of Dessau has taught us that there are still mines rich in ore, though they lie deep buried, and must be worked with more assiduity and with more care. I can conceive few more unpromising subjects, from which to extract a definite result, than were the solar spots when Schwabe first attacked them.

The only recent instance of perseverance, I can call to mind, comparable with the one before us, is that of Hencke, of Driessen, who is said to have spent the leisure of fifteen years in search of another planet; and at last, by the discovery of *Astræa*, gave the impulse which, responded to by Mr. Hind, De Gasparis, and others, has numerically increased more than four-fold the known members of the solar system. The achievement in either case may not fall within the category of works of genius—but both resulted from qualities of mind scarcely less rare than genius, and are precisely of a kind that genius alone never could accomplish.

The observations of Julius Schmidt, and Professor Wolf, lately

Digitized by Google

of Berne, now, I believe, of Zurich, who has regularly observed the spots since 1849, fully confirm the general accuracy of Schwabe's results. But we are naturally led to inquire whether we can connect them with the statements of former observers. Professor Wolf, who has entered deeply into the general question, published a few years ago, in the *Memoirs of the Philosophical Society of Berne*, all the notices he was able to find, scattered in books and memoirs, from the time of the discovery of the spots in 1611; and from a comparison of them with more modern determinations he deduced a period 11·1 years. Without depreciating the industry and ingenuity displayed in that paper, I confess I am not disposed to place much reliance on the result, owing to the insufficient data on which it appears to me to be founded. The inquiry is rendered very difficult, because the old observers attended much more to the physical characteristics of the spots, and to their time of rotation, than to their number. Moreover, I know only of Scheiner and Derham who observed them continuously for any length of time—that is to say, for more than two or three years. Scheiner's attention was almost exclusively directed to physical peculiarities; and Derham's investigations (*Phil. Trans.* 1711) were obviously very desultory.

Schwabe has not entered into speculations relative to the nature and origin of the spots, though he has been careful to note all remarkable appearances as they occurred; and of these he has given an admirable summary in the *Astronomische Nachrichten*, No. 473. There he calls attention to an appearance which, he says, is not uncommon, but which he cannot explain on the generally received theory, that the spots are portions of the surface of a solid body, seen through openings in a luminous atmosphere that surrounds it at a distance, and another intervening atmosphere. This theory of Sir W. Herschel, as you are aware, has been found adequate to explain most of the phenomena of the spots. But the case to which Schwabe alludes is this. On the above hypothesis a spot surrounded by a penumbra, will, by the effect of perspective, when it first makes its appearance on the disk, seem to be excentrically situated on the penumbra, the border of the penumbra towards the sun's centre appearing less broad than the other border. All this is intelligible,—but why is not the penumbra equally illuminated all round? For it frequently happens that the border turned towards the sun's centre is dark grey, while that towards the sun's limb is bright grey, and between the latter and the nucleus there is a string of light almost as bright as the sun's disk.

He also mentions having seen, though rarely, the phenomenon which, I find in Arago's notice of the life and works of Sir William Herschel, furnished Francis Wollaston, and Lalande, with an argument against Alexander Wilson, who was the first to advance the theory of the spots being cavities. The phenomenon is this:—Sometimes a spot surrounded by a penumbra passes over

Digitized by Google

the sun's disk without the former undergoing any change of relative position, from the beginning to the end of its course. This apparently militates against the cavity theory. Arago says the objection is not insurmountable. "Suppose," says he, "in such cases, that the sides of the openings in the photosphere, through which the spot appears, are not sloping." But according to Wilson's theory the penumbra is *formed* by the sloping sides of the photosphere—and there *is* the penumbra. Therefore it appears to me that this explanation does not hold good on Wilson's view. According to Sir W. Herschel another stratum is interposed between the solid body of the sun and the photosphere. On this hypothesis, it is the part we see of the secondary stratum which constitutes the penumbra; if therefore it be sensibly depressed below the surface of the photosphere a change of relative position must ensue. Schwabe's explanation is, that when the phenomena in question occur the secondary stratum has risen to an unusual height, and is *not* sensibly depressed below the photosphere.

There is another appearance, on which he lays much stress, "Lichtflocken," (light flakes,) which he conceives to be particles of matter, floating on the verge of our atmosphere. But I must not exhaust your patience by entering into details, and refer those who are interested in the subject to Schwabe's own excellent description in No. 350 of the *Astronomische Nachrichten*.

There is, however, one more topic too closely connected with our subject, and too remarkable to pass unnoticed.

You are aware, gentlemen, it has been long known that the intensity of magnetic declination is subject to a daily variation; and this variation was also known to be in some way connected with the sun, attaining its maximum western limit when that body is at its upper and lower culmination, and its maximum eastern limit about 6 o'clock in the morning and evening. These are not the exact times, but they are sufficiently near for our purpose. About the year 1850, Professor Lamont announced that this variation was again liable to another variation, which observed a period, from maximum to minimum, and from minimum to maximum, of about 10 years. He was led to this result by a discussion of his own observations at Munich. It was shortly after fully confirmed by our colleague, General Sabine, by the observations made at the Magnetic Observatories of Toronto and Hobarton. But in the course of the latter discussions General Sabine detected another important circumstance which had escaped Lamont, viz., that the periods of maximum variation of the declination-needle corresponded exactly with those of the maximum frequency of the solar spots, and *vice versâ*, the minimum of the one with the minimum of the other. Hardly had General Sabine's paper been read before the Royal Society on March 18, 1852, when intelligence was received that two Swiss physicists, Professor Gautier of Geneva, and Professor Wolf of Berne, had arrived at the same conclusion, independently of each other, from a perusal of Lamont's results.

Digitized by Google

All the observations I have mentioned, were made during nearly the same time—between the years 1840 and 1851—comprehending only a single period of change. Obviously, therefore, in this state of the inquiry it was of the highest importance to obtain a trustworthy series made at another time and under different circumstances. Though hardly to be expected, it happened, most fortunately, that such a series was at hand.

The diurnal variation was one of those subjects which, many years ago, had particularly interested the vigorous mind of the lamented Arago; and among his papers were found the records of a most laborious course of experiments, conducted with all the care which no one knew better than he how to bestow on a delicate investigation. These experiments, extending from 1820 to 1831, have been rigorously discussed by M. Thoman, and exhibit the prevalence of the same law that obtains in the later series.

Nor does the evidence of connexion rest here. In a recent paper sent to the Royal Society, General Sabine has shown that at Toronto (the only series hitherto fully discussed) all the magnetic elements subjected to observation undergo similar variations. In the face of these coincidences, to doubt the relationship between the two phenomena seems to me to be almost as unreasonable as to doubt the influence of the moon on the tides of the ocean.

M. Schwabe's service has been the discovery of an important astronomical fact, falling strictly within the cognisance of this Society. His merits are in no way affected, though, no doubt, the value of his discovery is enhanced, by this remarkable episode. No longer is its scope confined to the disclosure of a physical peculiarity in the constitution of the sun. It promises to be the means of revealing the prevalence of a principle, throughout the solar system, co-extensive with gravitation, and of establishing another link in the chain of analogies binding Earth with other worlds, the ultimate effect of which on the progress of physical research no one can foresee.

The President, then delivering the Medal to Mr. Carrington, addressed him in the following terms:—

I request you will transmit this medal to Mr. Schwabe with the expression of our highest admiration of the ability and zeal with which he has conducted his laborious series of observations on the solar spots—with our hearty congratulations on the results which he has already obtained, and on the bright prospect now opening of their augmented importance. Add, also, our best wishes that his life may be long spared to continue, and to see continued, the course of observations which he has so gloriously commenced.

Digitized by Google

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

GEORGE BISHOP, Esq. F.R.S.

Vice-Presidents:

Rev. GEORGE FISHER, M.A. F.R.S.
MANUEL J. JOHNSON, Esq., M.A. F.R.S. Radcliffe Observer
Rev. ROBERT MAIN, M.A.
Rev. BADEN POWELL, M.A. F.R.S.

Treasurer:

SAMUEL CHARLES WHITBREAD, Esq., F.R.S.

Secretaries:

RICHARD C. CARRINGTON, Esq.
WARREN DE LA RUE, Esq. F.R.S.

Foreign Secretary:

JOHN RUSSELL HIND, Esq. Superintendent of the Nautical Almanac.

Council:

G. B. AIRY, Esq. M.A. F.R.S. Astronomer Royal.
AUGUSTUS DE MORGAN, Esq.
JAMES GLAISHER, Esq. F.R.S.
ROBERT GRANT, Esq. M.A.
JOHN LEE, Esq. LL.D. F.R.S.
Admiral R. H. MANNERS.
CHARLES MAY, Esq. F.R.S.
Rev. C. PRITCHARD, F.R.S.
WILLIAM SIMMS, Esq. F.R.S.
Admiral W. H. SMYTH, K.S.F. D.C.L. F.R.S.

The Astronomer Royal has kindly announced that he is prepared to give an oral lecture at the Meeting of the Society, on the 8th of April next, on "The Means that will be available for Correcting the Measure of the Sun's Distance for several years to come," including, with other things, the Transits of *Venus* of 1874 and 1882.

Digitized by Google

ERRATA.

Vol. XVII., page 5, line 13, *for* of the bright edge, *read* at the bright edge.

— — — 10, — 10, *for* 27°, *read* 270.

— — — 23, — 12, *for* observation, *read* obscuration.

— — — 29, in Mr. Tennant's paper, throughout, *for* frustrum, *read* frustum.

London:—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, March 27, 1857.

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *March* 13, 1857. No. 5.

REV. BADEN POWELL, V.P., in the Chair.

James Simms, Esq., Carshalton;
W. J. Gillett, Esq., Harley Street; and
Capt. R. Fitzroy, R.N.;
were balloted for and duly elected Fellows of the Society.

For notice of two new comets, see page 161.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Months of January and February, 1857.

(*Communicated by the Astronomer Royal.*)

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	° ′ ″
1857, Jan. 2	8 38 12·58	3 27 54·07	61 52 5·31
16	7 44 42·73	3 29 27·26	62 25 49·13
19	7 34 4·23	3 30 36·68	62 30 31·60
23	7 20 18·75	3 32 35·17	62 35 26·00

Hebe.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Feb. 16	11 57 57·46	9 45 36·84	73 38 22·44
23	11 24 8·56	9 39 18·27	72 32 0·08
24	11 19 21·08	9 38 26·57	72 23 1·04
26	11 9 48·49	9 36 45·52	72 5 31·12

Digitized by Google

Parthenope.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 31 14 3 34·13	10 48 29·25	79 14 32·27
Feb. 16 12 48 21·71	10 36 9·38	77 28 14·41
24 12 9 40·27	10 28 54·02	76 32 40·11
26 11 59 58·41	10 27 3·67	76 19 9·74
28 11 50 16·96	10 25 13·75	76 6 0·06

Lutetia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 19. 8 12(30)	.....	68 45 51·19
Feb. 14 6 40 47·98	4 19 42·14	67 59 15·60

There is some doubt whether the above places are those of *Lutetia*.

Fides.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 27 14 46 21·55	11 15 37·48	82 16 40·23
Feb. 16 13 14 15·20	11 2 7·12	81 3 2·06
24 12 35 38·04	10 54 56·05	80 26 37·02
26 12 25 54·71	10 53 4·23	80 17 24·28

The Occultations of Jupiter and his Satellites on the 2d of January, as observed at the Cambridge Observatory. By Professor Challis.

"I delayed sending to the Astronomical Society my observations of the occultation of *Jupiter*, till I could complete certain calculations founded upon them, which proved to be long and intricate. The results of the calculations are added to the following account of the observations.

"Expecting a good opportunity, I made every requisite preparation for observing the occultations with the Northumberland equatorial. My junior assistant, Mr. Taylor, counted from a chronometer, and recorded the times; so that, while observing

Digitized by Google

the times of immersion and emersion, I was at liberty to notice physical phenomena. The magnifying power employed was 215. Mr. Breen observed, by himself, with the 5-feet equatorial, using a power of 120. The following are the Greenwich mean times of the occurrences, as deduced from the noted times of the two observers. The letters C and B indicate the observers.

Greenwich Mean Times of Disappearances.

	C	B	
	h m s	s	
Satellite IV.	4 45 31·46	31·60	(*a*)
— III.	4 53 2·47	3·47	(*b*)
Jupiter, beginning	4 59 47·98	50·35	(*c*)
— end	5 1 27·18	27·19	(*d*)
Satellite I.	5 2 16·48	16·85	(*e*)
— II.	5 3 29·05	27·98	(*f*)

Greenwich Mean Times of Reappearances.

	C	B	
	h m s	s	
Satellite IV.	5 38 32·54	...	(*g*)
— III.	5 49 52·55[1]	32·20	(*h*)
Jupiter, beginning	5 59 13·57	18·40	(*i*)
—, end	6 0 44·77	44·56	(*k*)
Satellite I.	6 1 57·07	71·91	(*l*)
— II.	6 3 40·57	58·33	(*m*)

"The following are the notes which I made in the observing-room immediately after the respective observations:—

"'(*a*) The satellite disappeared gradually: the time noted is the mean between the beginning and end of obscuration, which occupied about $1\frac{1}{2}^s$. (*b*) Gradually, as before. It first appeared cut off a second earlier: the time noted is that of bisection of the satellite by the moon's limb. (*c*) The time of first contact, perhaps, a little late: half a second after the recorded time the limb was quite perceptibly cut off. (*d*) This time is very exact. (*e*) Time of bisection: disappeared rather more suddenly than the two preceding. (*f*) Occupied in disappearing about the same time as satellite I.

"'During the occultation of *Jupiter* I noticed particularly the form of his disk. I could not perceive any elongation of the line of section by the moon's limb, the contour of *Jupiter* appearing continually round. I lost the impression of his oblateness. The moon's limb was faintly visible. When *Jupiter* was about half cut off, I remarked that the section was rather jagged, and in particular that there was a bright projection at about the middle point.

"'(*g*) First seen at this time, when it was about 4″·5 from

[1] An error of 20ˢ in recording.

Digitized by Google

the limb. (*h*) First seen at 2″ from the limb. (*i*) Time rather late: the limb projected perhaps 2″·5. (*k*) This is exact. (*l*) 2″ from the limb. (*m*) Good: the satellite seen adhering to the limb.

"'I thought *Jupiter*, at reappearance, seemed flattened towards the moon's limb. My attention was a good deal directed to a faintish shadow running along the moon's limb, and of about 4″ in breadth. This continued during the whole of the reappearance. Just at the total emergence the point of contact was obscure, and seemed to recede from the moon's limb. Perhaps the noted time of complete emergence may, on this account, be a little too early. The emergence took place at a depression of the moon's limb, extending beyond *Jupiter* on both sides. This was very conspicuous. The moon's irradiation appeared cut off at this part.'

"Mr. Breen noted as follows:—

"'Times of disappearing beautifully exact. The satellites were about $1\frac{1}{2}^s$ in disappearing. Circumstances very favourable. No perceptible distortion in the form of *Jupiter:* its oblate shape very noticeable during the time of its disappearance.

"'The observations of reappearance satisfactory, but those of the satellites not as good as the observations of disappearances. They appeared *instantaneously*. During the time of emersion *Jupiter* seemed indented into the moon's limb. No distortion of its shape was noticed.'

"To the foregoing rough notes I beg to add a few remarks. The atmospheric circumstances of the observations were particularly good; both *Jupiter* and the moon's limb appearing at times with extraordinary definition. This was remarkably the case at *Jupiter's* emergence, the moon's limb during the whole time and after being quite sharp and free from irradiation. The planet, when fairly separated, was strikingly beautiful: its contour and belts were steady and distinct: being visibly brighter at the central part of the disk than towards the border, it had something of a pellucid appearance: its light was pale compared to that of the moon, and had the slightest possible tinge of olive green. The most remarkable phenomenon was the dark fringe bordering the moon's limb: it was darker than *Jupiter's* belts; and continuing to the end of the emersion, made the observation of last contact somewhat difficult. This circumstance seems to prove that the fringe could not be the mere effect of contrast between the moon's light and that of *Jupiter*. Describing it after the observation, I said it reminded me of *Saturn's* dusky ring. The bright projection noticed at the immersion was due to an indent in the moon's limb, and its brightness was probably remarked in consequence of its being situated between the two principal belts. This observation seems to show that no such phenomenon as the dark fringe occurred at the immersion. Can this phenomenon be connected in any way with the circumstance that the emersion took place at a depressed part of the moon's limb? I made an attempt to measure

Digitized by Google

the depth of the depression when the moon was of the same age in the next lunation, and obtained, with some uncertainty, 1″·8, the state of the atmosphere not being favourable. I have no reason to conclude that the form of *Jupiter* suffered distortion either at immersion or emersion, the flattened appearance which I noticed at emersion being probably only the oblateness.

"The estimations of the distances of the objects from the moon's limb when first seen on reappearance, were made by means of the known interval between the teeth of the micrometer-comb. This method of estimation was subsequently verified by first estimating and then reading off intervals between the micrometer wires. The emersion of the 4th satellite was seen late from my not being prepared for it, and not knowing exactly where to look. I can hardly account for not seeing the 3d and 1st satellites and *Jupiter's* 1st limb earlier, as they were looked for in the right places. They seemed to come into view suddenly. Mr. Breen's times of emersion of the 1st and 2d satellites were proved by calculation to be much too late.

Calculation, from the foregoing Observations, of the Positions of the Satellites relative to Jupiter's Centre.

"Let p be the difference of apparent R.A., estimated on the arc of a great circle, and q the difference of apparent N.P.D. of *Jupiter's* centre, or a satellite, and the moon's centre, at the noted time of immersion, and $p + \alpha$, $q + \beta$, the same for that of emersion. Then, S being the moon's apparent semidiameter at the first time, and S + ϵ the apparent semidiameter at the second time, inclusive of estimated distance from the moon's limb, we shall have very nearly—

$$p^2 + q^2 = S^2 \text{ and } (p + \alpha)^2 + (q + \beta)^2 = (S + \epsilon)^2.$$

"Consequently if $\frac{q}{p} = \tan \varphi$ and $\frac{\beta}{\alpha} = \tan \theta$, the following equations determine φ, p and q:

$$\cos(\varphi - \theta) = -\frac{\alpha}{2 S \cos \theta} + \frac{\epsilon \cos \theta}{\alpha}\left(1 + \frac{\epsilon}{2 S}\right)$$

$$p = S \cos \varphi, \quad q = S \sin \varphi.$$

"To effect the calculations by these formulæ, the differences of the apparent R.A. and N.P.D. of the moon and *Jupiter*, and the moon's apparent semidiameter, at 4^h, 5^h, 6^h, and 7^h, were first calculated from the tables: whence α, β, and S, were inferred by interpolation to second or third differences. The calculations having been gone through for the times of immersion and emersion of *Jupiter's* centre, the resulting values of p and q showed that the tabular excess of the moon's apparent R.A. above that of *Jupiter* required the correction — 5″·48, and the tabular excess of apparent N.P.D. the correction + 7″·30.

"To find α and β for a satellite, it was necessary to take account

Digitized by Google

of the satellite's motion in R.A. and N.P.D. between the immersion and emersion. This was done by means of the data for calculating the co-ordinates x and y relative to *Jupiter*, which are given for each satellite in the Berlin Ephemeris. The direction of the axis of x was first assumed approximately, and the error of the assumption then corrected by the result of the calculation. The differences of the R.A. and N.P.D. of the moon and satellite were then deduced from the above formulæ for the time of immersion, and the corrected differences of R.A. and N.P.D. of the moon and *Jupiter* for the same time being known, those of *Jupiter* and the satellite were immediately inferred. The following are the principal results of the calculations:—

Greenwich M.T.	Satellite.	Jupiter — Satellite, R.A.	Jupiter — Satellite, N.P.D.	Distance from Jupiter by Observation.	Tabular Distance.	Excess of Observation.
h m s		″	″	″	″	″
5 2 16·7	I.	+ 57·07	− 20·59	60·67	57·00	+3·67
5 3 28·5	II.	+ 94·29	− 36·61	101·08	92·22	+8·86
4 53 2·5	III.	−220·04	+111·04	246·47	240·94	+5·53
4 45 31·5	IV.	−458·35	+221·02	508·86	502·55	+6·31

"These results depend on the assumed values of the semidiameters of the moon and *Jupiter*, which were taken without alteration from the *Nautical Almanac*. *Jupiter's* equatorial diameter, as inferred from the interval occupied by the immersion, the form of the disk being taken into account, is found to be 19″·14, which probably should be increased by a small fraction of a second, it being scarcely possible by this kind of observation to obtain the full amount of the diameter. The value inferred from the duration of the emersion, and corrected by + 1″·25 for the estimated distance of *Jupiter's* first limb from the moon, is 18″·43. The assumed tabular value is 19″·59. It would thus appear that the assumed semidiameter is at least not too small, and consequently that the above excesses of observation indicate that the ratios of the mean distances of the satellites to *Jupiter's* equatorial semidiameter, as given in the Berlin Ephemeris, require some correction. No attempt has been made to take into account the effect of the depression of the moon's limb at the place of emergence."

Mr. R. C. May, of No. 4 Sloane Terrace, also witnessed the dark shadow on the disk of *Jupiter*, seen by so many other observers. He forwarded a very well-executed drawing, almost identical with those of Mr. Lassell and the Messrs. Simms, in our previously published accounts. The telescope used by Mr. May was a Newtonian of 6 feet focus, and 6·9 inches aperture, made by himself. The magnifying power employed was not stated.

Digitized by Google

Mr. James Nasmyth, in a letter to Mr. De la Rue, states that he observed the occultation of *Jupiter*, on Jan. 2, very favourably at Doncaster with one of his 10-inch metals, and a power of 150. He watched anxiously for any indications of a lunar atmosphere, and noticed that at the immersion, instead of any decrease of the brightness of the disk at the time of intersection, there was *visibly* more light there, and at the emersion a dark shadow in contiguity to the bright limb of the moon. Both of these appearances Mr. Nasmyth, no doubt correctly, attributes to the usual effect of contrast. He saw no symptoms of distortion.

Note on the Lunar Occultation of 27 Arietis, on 1857, Feb. 28; observed at Haddenham, Bucks. By the Rev. W. R. Dawes.

"The lunar occultation of 27 *Arietis*, a star of the sixth magnitude, as seen from this place on the 28th of February last, afforded a fine opportunity of watching the effect of an extremely oblique approach of the moon's obscure limb, which was within a few seconds of the star for more than a minute. The 8-inch equatoreal refractor in my observatory having been directed to the star with a power of 172, I carefully noted the appearance of its disk for about ten minutes before the occultation, that my eye might become familiar with the variations of its appearance produced by the condition of our atmosphere. These, however, were not great, the air being generally in a very favourable state, with only occasional and very transient fits of indistinctness. The disk of the star was very sharply defined and steady. To assist my eye in judging of any extraordinary change in its apparent place, I brought it to one of the angles formed by two thick spider's webs crossing in the centre of the field, and within a distance from them of about two of its own diameters; keeping it there by the equable motion of the driving-clock. The moon's obscure limb was distinctly visible. Not the slightest change took place in the star's position, or brightness, or steadiness, or sharpness of definition, while in close proximity to the moon; and at length it disappeared instantaneously and without any warning whatever.

"In my account of the lunar occultation of *Jupiter* in January last, I mentioned a bluish fringe attached to the moon's bright limb, and visible at the reappearance of the planet across its disk. This, from its colour, I attributed to the secondary spectrum of the object-glass. A similar dark fringe was noticed also by Mr. Simms on the same occasion; and, though the colour is not mentioned, this might also be attributed to the same cause. But, as the same phenomenon, so far as its darkness is concerned, was also seen by Mr. Lassell, who observed with his large reflector, some other cause must have contributed in a great degree to produce it; and it has occurred to me, that the shading, apart from

Digitized by Google

the colour, might be simply the effect of the great contrast between the brilliancy of the moon's limb and the comparative paleness of the planet. The phenomenon may be imitated artificially by placing a white disk close behind the edge of a bright flame; when a very narrow shading, as if with pencil, darkest close to the flame, and rapidly becoming lighter, will appear across the disk.

"It seems to be obviously impossible that the cause of the dark line on the planet should be any atmospheric or other substance attached to the moon. No appearance of the kind was seen at *Jupiter's* occultation at the dark limb; the disk being uniformly bright up to the very edge of the moon, the minutest inequalities of which were plainly visible and sharply defined. Yet it is especially, and perhaps only, at the dark edge that any such effect of a lunar atmosphere might be expected to be discernible: for at the bright edge the atmosphere would itself be highly illuminated; and, therefore, though if of considerable density it might impair the clear definition of the edges and belts of *Jupiter*, it is difficult to conceive how it could appear upon its disk as a dark shading.—The unaltered brightness of very small stars occulted at the dark edge of the young moon, or during a total lunar eclipse, would seem also conclusively to prove that there can exist no atmospheric envelope capable of producing any effects visible to us."

Haddenham, Bucks, 1857, March 11.

Mr. Hippisley, of Ston Easton, near Bath, in a paper which we had not space to notice before, relates an experiment which he lately performed for his own satisfaction, illustrative of the projection of stars on the disk of the moon. He formed an artificial star with a candle placed at a distance of about 185 yards, and an artificial moon with a disk of card attached to a rod applied to the end of his telescope. Illuminating his artificial moon, he was able to make the relative brightnesses of the artificial moon and star nearly in the proportion of nature, and to make the appulse as gradual as he pleased. He thus had an opportunity, he says, of witnessing the overlapping of the two images at leisure, and of convincing himself of the sufficiency of optical considerations for the explanation of what he saw.

On the same subject, but referring more especially to Captain Jacob's note published in page 17 of the current volume, Mr. Lassell mentions an occultation of *Aldebaran*, as far back as the 22d of August 1829, in which he witnessed a distinct entry of the star on to the moon's disk. In the extract of his diary, which was

Digitized by Google

forwarded, it is related that the star progressed steadily till the moment when it was just wholly within the lunar edge, and then vanished instantaneously. Mr. Lassell remarks, that a star being an indivisible point, and its apparent disk spurious, we might expect to see one-half of the disk thus overlapping the moon's, and that the perplexity felt in seeking an explanation attaches rather to the outer half-disk.

The Astronomer Royal, regarding the reality of the phenomenon as thoroughly established by the concurrent testimony of many able observers, calls attention to the circumstance of its being most frequently and strikingly exhibited in the case of *Aldebaran* and the red stars. He suggests that all occultations of *Aldebaran* should be carefully tabulated, with accounts of the circumstances of the observations, and divided into two classes, one in which the star was situated above the centre of the moon, and the other in which it was below, and that the difference of refraction of the white and red rays should be well weighed as a possible contributing cause.

On Optical Phenomena in Occultations. By the Rev. Baden Powell, M.A., F.R.S., F.R.A.S., Savilian Professor of Geometry in the University of Oxford.

"The singular optical appearances so often witnessed in occultations and allied phenomena, have been ascribed (as is well known) to several causes, (1.) instrumental, or properly optical; (2.) ocular, or personal; (3.) atmospheric, whether lunar, planetary, or terrestrial; or to some combinations of these.

"So far as causes *properly optical* are concerned, I have examined the recorded observations in all the recent cases, with a view to obtain, if possible, some data, especially as referring to the hypothesis of 'irradiation,' or 'diffraction of the object-glass.' In this case, as I have pointed out in a paper in the *Memoirs* of this Society,[1] the essential element *in theory* is the *ratio of the aperture to the focal length* of the telescope employed; the diffraction increasing with the *relative* diminution of the aperture; though, *cæteris paribus*, the effect will be increased by greater *absolute* aperture (*i. e.* more light), and diminished by higher power, *i. e.* diminished intensity of light.

"As on a former parallel occasion,[2] so in reference to recent instances, I have collected, in the annexed tabular view, the data belonging to the several instruments employed; which have been in many instances kindly furnished by the respective observers, beyond the particulars given in the *Notices*.

[1] Astronomical Society's *Memoirs*, Vol. xviii. p. 69.
[2] Astronomical Society's *Memoirs*, Vol. xxi. pt. I. p. 116.

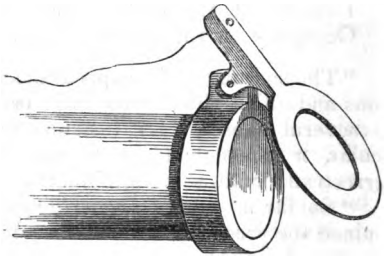
Digitized by Google

"The several cases are arranged in the order of the magnitudes of the *ratio of aperture to focal length.*

"Under the head of 'Phenomena' I have merely designated in the briefest terms possible those appearances described, which seem likely to have any optical relations; presuming the accounts in the *Notices* to be known to the reader. I may add that Mr. Peto, in a letter to me, speaks of the projection which he witnessed as of the limb of *Jupiter indenting* that of the moon, and marked by the dark border observed in so many other cases. He gives a sketch, which seems exactly to agree with the appearance noticed by Professor Challis, which he ascribes to the emergence taking place at a part of the moon's limb where there was a depression. This description might consist with a projection as supposed by Mr. Peto.

"The peculiar halo of light after the disappearance of the satellite noticed by Mr. Brodie, and also, as he informs me, by a friend using the telescope formerly Dr. Pearson's,—as well as the light appearing on the moon at, or after, the immersion of the planet, noticed by several observers—though ascribed by some to a lunar atmosphere—seem to me phenomena apparently allied to those I have formerly adverted to,[1] occasioned by a divergence of light.

"For instantaneously applying or removing a contracted aperture to or from the object-glass, I have found very effective the simple contrivance represented in the annexed sketch, which requires no description, and is effected by merely pulling the string. Several diaphragms with different apertures might be applied over each other in the same way. I made a rough trial of this method in the late occultation, making several alternations during the immersion: but saw no change. Perhaps, however, the loss of light was too great.



Occultation of Jupiter by the Moon, January 2, 1857.

(*See Astronomical Society's Notices*, vol. xvii. No. 3.)

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomena.
	ft. in.	in.			
Baxendell (Newtonian)	9 0	13·0	$\frac{1}{8·3}$	...	Imm., light on ♃.
Hippisley (Newtonian)	7 4	9·25	$\frac{1}{9·4}$	60	Imm., flattening of ♃. Em., dark shade.
Criswick (Greenwich, W. Equat[l].)	3 0	3·6	$\frac{1}{10}$	...	Em., projection of ♃'s limb.

[1] Astronomical Society's *Memoirs*, Vol. xvi. p. 301.

Digitized by Google

Observer.	Focal Length = F. ft.	in.	Aperture = A. in.	Ratio $\frac{A}{F}$	Power.	Phenomena.
Glaisher (Greenwich, 30-in. Achr.)	2	6	2·7	$\frac{1}{11·1}$	...	None.
Huggins	5	0	5·0	$\frac{1}{12}$	50	None.
Lassell (Newtonian)	20	0	20·0 (reduced)	$\frac{1}{12}$	316	Imm., distortion of ♅; Em., dark shade.
Lowndes (Adm^{l} Smyth's Equatoreal)	8	6	5·9	$\frac{1}{12·1}$	240	Imm., distortion of ♅.
Dawes (Alvan Clark)	10	0	8·0	$\frac{1}{12·5}$	160	Imm., light on dark limb of ☽.
Ellis (Greenwich, 46-in. Achr.)	3	10	3·6	$\frac{1}{13}$	170	None.
Simms (1)	2	6	2·25	$\frac{1}{13·3}$	...	Em., dark shade.
Grove (Binocular)	4	3	3·37	$\frac{1}{13·4}$	60	None, though looked for.
Watson (Newtonian)	9	0	8·0	$\frac{1}{13·5}$	100	None.
Mann	4	0	3·5	$\frac{1}{13·6}$	120	Em., ♅ preceded by patch of light on moon (projection?) Dark shade.
Simms (2)	6	4	5·5	$\frac{1}{13·8}$	...	Em., dark shade.
Lord Wrottesley	10	9	7·75	$\frac{1}{14·1}$	140	Imm., light on dark limb of ☽.
Main (Greenwich, S. Equat^{l}.)	8	2	6·7	$\frac{1}{14·6}$	...	Imm., distortion of limb of ♅; bright band on ♅; repetition of disappearance.
Brodie (1)	9	5	7·45	$\frac{1}{15·1}$	106	Imm., projection of sat.; light outside limb of ☽ after disappearance.
Webb	5	6	3·7	$\frac{1}{15·2}$	144	Imm., light on limb of ☽ after disappearance. Em., dark shade.
Burr	4	4	3·38	$\frac{1}{15·4}$	173	Imm., light on limb of ☽.
Peto	5	0	3·875	$\frac{1}{15·4}$	120	Em., projection of ♅, with dark shade (*qy.* same as Challis?)
Dunkin (Greenwich, N. Equat^{l}.)	5	4	4·1	$\frac{1}{15·8}$	...	Imm., light on dark limb of ☽.
Lynn (Greenwich, Altazimuth.)	5	0	3·75	$\frac{1}{16}$	...	None.

Digitized by Google

Observer.	Focal Length = F. ft. in.	Aperture = A. in.	Ratio $\frac{A}{F}$	Power.	Phenomena.
Hodgson	8 0	6·0	$\frac{1}{16}$	160	None.
Pogson	10?	7·2	$\frac{1}{16·7}$	93	None.
Johnson (Heliometer)	10 5	7·5	$\frac{1}{16·8}$	150	None.
Hartnup	12 0	8·5	$\frac{1}{16·9}$	134	Em., projection of sat.
Simms (3)	22 0	15·0	$\frac{1}{17·6}$	200	Imm., distortion of ♄.
Slatter	7 4.	4·9	$\frac{1}{17·9}$	87	Em., sat. adhered, and suddenly separated.
Simms (4)	22 0	13·0	$\frac{1}{20·3}$	200	Em., dark shade.
Challis (Northumberl[d])	19 6	11·5	$\frac{1}{20·3}$	215	Em., ♄ as if in a hollow of ☽; dark shade (*qy.* projection ?)
Brodie (2) a friend, (Dr. Pearson's)	12 0	6·8	$\frac{1}{21}$	...	Same as Brodie (1).

Occultation of Jupiter by the Moon, November 8, 1856.

(*Astronomical Society's Notices*, vol. xvii. No. 1.)

Observer.	Focal Length = F. ft. in.	Aperture = A. in.	Ratio $\frac{A}{F}$	Power.	Phenomena.
De La Rue (1) (Newtonian)	9 11½	13·0	$\frac{1}{9·2}$	...	None.
Huggins	5 0	5·0	$\frac{1}{12}$	176 (corrected)	♄ grazed ☽.
Grove	1 10	1·75	$\frac{1}{12·5}$	43	Imm., junction of limbs; dark shade.
De La Rue (2) (Achrom.)	3 0	2·5	$\frac{1}{14·4}$	...	None.
Burr	4 4	3·38	$\frac{1}{15·4}$	...	Imm., ♄ grazed ☽; dark shade.
(also Jan. 2d) Goddard	6 2	4·125	$\frac{1}{17·9}$	200	Imm., adhesion; dark shade.

Eclipse of Jupiter's First Satellite, January 3, 1857.

Observer.	Focal Length = F. ft.	Aperture = A. in.	Ratio $\frac{A}{F}$	Power.	Phenomenon.
Hodgson	8	6	$\frac{1}{16·0}$	140	Projection of sat. on ♄.

Digitized by Google

Occultation of Jupiter by the Moon, August 19, 1856 (*Canada*).

(*Astronomical Society's Notices*, vol. xii. p. 221.)

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomenon.
	ft. in.	in.			
Chalmers	3 16	2·75	$\frac{1}{14·4}$	60	Apparent repulsion of contact.

"From this tabular view it appears that all the cases of projection (or what appear such),—or others which may be conceived due to similar optical causes,—occur with telescopes having ratios between $\frac{1}{13}$ and $\frac{1}{20}$; with the single exception of that of Mr. Criswick, with a ratio of only $\frac{1}{10}$. Yet that gentleman's description of the phenomenon is graphically what ought to be the optical effect due to enlargement of the disk.

"We have as yet no data for assigning the limits of this telescopic ratio for producing enlargement of disks; but generally in this instance they do not appear to follow any perceptible relation to the size or perfection of the instruments. We must still suppose them in a great degree due to *ocular* causes as yet little understood."

Abstract of a Paper "On the Horary Variation of Meteors." By G. C. Bompas, Esq.

(*Communicated by Professor De Morgan.*)

The fact of a *horary* variation in the number of shooting stars observed has been established by the researches of Coulvier Gravier, Saigey, and others.—(*Recherches sur les Etoiles Filantes*, Paris, 1845; and Humboldt *Cosmos*, iii. 440.)

The following table contains a summary of these results:—

Hours, P.M.	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12
Mean No. of Meteors.	3·3	3·5	3·7	4	4·5	5

Hours, A.M.	12 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6
Mean No. of Meteors.	5·8	6·4	7·1	7·8	8	8·2

Thus it appears that the minimum occurs at 6 P.M.; the mean at midnight; and the maximum at 6 A.M.; and that two-thirds of the whole number appear between midnight and 6 A.M.

If we designate the number coming from N, S, E, and W, by those initials respectively, then $E > 2W$, $N = S$ nearly, but $E + W = N + S$.

Digitized by Google

Coulvier Gravier observes,—"But for *the cause* which transfers from the west to the east nearly one-half the number due to each of these directions, there would come exactly the same numbers of shooting stars from the four points of the compass." But he does not state what that cause is.

From the results of all these observations it appears that the greatest *heights* at which meteors appear bear no more than a very small proportion to the earth's diameter.

Boguslawski considers the average *velocity* of meteors to be about *double* the velocity of the earth in its orbit.—(*Etoiles Filantes*, p. 102.)

The part of the heavens towards which the earth is moving at any time is always 6^h from the ☉. At 6 A.M. the observer's meridian is in the direction of the earth's motion: and at 6 P.M. in the opposite.

Thus the greatest number of meteors are encountered when the observer's meridian is in the direction of the earth's motion; and the number diminishes from thence to 6 P.M., when he looks the opposite way.

Combining these facts, the author explains the results (illustrated by a diagram), on the principle that if the meteors be distributed equally in space they would converge to the earth, if at rest, equally on all sides.

But if the earth be in motion, and with a velocity one-half the average velocity of the meteors, they would converge to it more on the side towards which it is moving than the other: and, in the proportion of nearly two-thirds of the number, would have an apparent motion more or less opposed to that of the earth, and apparently diverging from the point towards which the earth is moving with a gradual increase in number from 6 P.M. to 6 A.M.

The work of Coulvier Gravier and Saigey here referred to contains a very full historical summary of all that has hitherto been done in the study of meteors, and was apparently intended as the preface to a series of observations which, so far as we are aware, has not yet appeared. The work of Mr. Schmidt, *Resultate aus zehnjahrigen Beobachtungen über Sternschnuppen*, published in 1852, requires no recommendation to readers of German.

Extract from a Letter from Professor Argelander.

"I have read with much pleasure in the last number of the *Monthly Notices* the paper of Mr. Pogson on variable stars. Mr. Pogson has, by his communication on these interesting objects, acquired new laurels; and every one who is employed in observations of them will thank him for his published times of maxima

Digitized by Google

and minima. For the stars which are constantly visible the knowledge of these times is in some respects of less importance, and it is very much to be wished that they should be closely looked after in all stages of their variability, and be observed by many more astronomers. But for the great number of these stars, which are only visible for a short time even in large telescopes, a previous approximate knowledge of their times is indispensably necessary for the observer to escape from the needless loss of time caused by frequent fruitless searches. Indeed without such previous warning many a phenomenon would pass altogether unobserved.

"The numbers given by Mr. Pogson do not, however, appear to be all based on the most certain elements; for instance, those for the older stars seem for the most part to be derived from my contributions to the *Cosmos* of Humboldt. Since the publication of these contributions our knowledge of the elements of the variability of many of those changing stars has, however, been greatly increased, so that the older elements are now comparatively no longer of use. I beg, therefore, to communicate some corrections, with the request that they may be made known through the *Monthly Notices*.

"I give, firstly, the times of maxima in the present year for those stars for which my further researches have supplied corrections to my earlier elements:—

R Cancri,	Maximum,	1857,	Feb. 23
R Leonis,	—	—	June 21
S Serpentis	—	—	April 5
R Serpentis	—	—	Sept. 29
χ Cygni	—	—	Dec. 19
R Pegasi	—	—	March 5
R Aquarii	—	—	April 16
μ Cephei	—	—	April or May.

μ Cephei is Herschel's Garnet star.

"α *Cassiopeæ*, ι *Aurigæ*, R *Coronæ*, and β *Pegasi* are only occasionally variable; R *Hydræ*, α *Herculis*, and R *Scuti*, are, as Mr. Pogson has already remarked, very irregular: the minima of R *Scuti* ought to occur about Feb. 9, April 21, July 2, Sept. 12, and Nov. 23, and the maxima 40 days after the minima; but these times may fluctuate 15 or 20 days.

"For the calculation of the epochs of the short-period-variables the following data are available:—

ζ Geminorum — Minimum, 1857, Feb. $7^d\ 7^h{\cdot}2$, G.M.T.
Period, $10^d\ 3^h\ 48^m{\cdot}0$. Max. $5^d\ 5^h{\cdot}5$ after the Min.

Observations are well represented by the formula,—

$$1857, \text{Jan. } 7^d\ 19^h\ 51^m{\cdot}2 + 10^d\ 3^h\ 47^m\ 59^s{\cdot}4\ E + 1^s\ E^2;$$

where E is the number of periods elapsed from 1857, Jan. 7.

Digitized by Google

β Lyræ — Principal minimum, 1857, Feb. $6^d\ 1^h\ 54^m{\cdot}0$, G.M.T.
Period, $12^d\ 21^h\ 45^m\ 12^s$. First max. $3^d\ 2^h$; second min. $6^h\ 8^h{\cdot}5$, and second max. 9^h 10^d after the minimum.
Its periods are slowly decreasing.

η Aquilæ — Minimum, 1857, Feb. $6^d\ 14^h\ 3^m{\cdot}2$, G.M.T.
Period, $7^d\ 4^h\ 14^m\ 4^s$. Max. $2^d\ 9^h$ after the min.

δ Cephei — Minimum, 1857, Feb. $6^d\ 1^h\ 14^m{\cdot}3$, G.M.T.
Period, $5^d\ 8^h\ 47^m\ 40^s{\cdot}0$. Max. $1^d\ 14^h{\cdot}4$ after the min.

"It is much to be wished that observers in the southern hemisphere would attend to the observation of R *Hydræ*. This star is visible but for a very short time to us, especially if it is not observed in the morning, a time when the professional astronomer can seldom attend to it. Besides which, suitable stars of comparison at the maximum are wanting: ψ and γ *Hydræ* being so very different in brightness that the comparison can no longer be made with security when the variable is between the two, and thereby the time of maximum is very uncertain.

"Comparison-stars of intermediate brightness, which are only to be found in *Scorpio*, are too low on our horizon in Europe to be used with advantage. All these difficulties are absent to the southern observer. It is to these obstacles that we must attribute the circumstance that the elements of variability of a star so long known as this one has been are still almost wholly unknown. Its period is now manifestly shorter than it was 150 years ago, but the want of a continuous series of observations prevents our drawing any conclusions respecting its rate of diminution; and if our information is to be confined to observations procured in the northern hemisphere, it may, perhaps, happen that 150 years hence we may not know much more about it than at present."

Supplement to the Solar Tables of Messrs. Hansen and Olufsen. By P. A. Hansen.

(*Communicated by the Astronomer Royal.*)

In calculating the positions of the Sun for certain ancient eclipses, I have found that by means of the terms of the first and second order depending on the precession, of which Mr. Olufsen and I have taken account in our tables, we do not obtain the position of the Sun for times so distant from the epoch of the tables with all the precision which is desirable. I feel bound, accordingly, to add the terms of the third and fourth order, which have a sensible effect at those distant dates. By carrying farther

Digitized by Google

the developments we find in the quantities designated by Z and W the following terms:—

In Z,

$$\left\{\begin{array}{llll} & + 0''.001979 & \sin(g'' + Xt) + 0''.000084 & \sin 2(g'' + Xt) \\ - 0.000469 & + 0.007912 & \cos(g'' + Xt) + 0.000037 & \cos 2(g'' + Xt) \end{array}\right\} T^3$$

$$+ \left\{\begin{array}{llll} & - 0.0000015 & \sin(g'' + Xt) + 0.0000015 & \sin 2(g'' + Xt) \\ - 0.0000002 & - 0.0000009 & \cos(g'' + Xt) - 0.0000003 & \cos 2(g'' + Xt) \end{array}\right\} T^4$$

In W,

$$\left\{\begin{array}{llll} - 0.00074 & - 0.02081 & \cos(g'' + Xt) - 0.00122 & \cos 2(g'' + Xt) \\ & + 0.08341 & \sin(g'' + Xt) + 0.00175 & \sin 2(g'' + Xt) \end{array}\right\} T^3$$

$$+ \left\{\begin{array}{llll} - 0.000018 & + 0.000014 & \cos(g'' + Xt) - 0.000015 & \cos 2(g'' + Xt) \\ & - 0.000011 & \sin(g'' + Xt) - 0.000005 & \sin 2(g'' + Xt) \end{array}\right\} T^4$$

where $$T = \frac{t - 1850}{100}$$

In the Solar Tables we have not included the preceding terms, which, in point of fact, amount to a few seconds only for a thousand years before or after their epoch, considering such an approximation to be sufficient. But as some of the ancient eclipses reach back to more than 2500 before the epoch of the tables, and for this interval of time the terms involving T^3 may amount to more than two minutes, we cannot neglect them when we wish to know exactly the results of the lunar tables for these eclipses.

I supply, then, on this occasion the necessary tables for these terms, with the addition of the coefficients of T^4, although the latter amount to a few seconds only, even for 2500 years. The units adopted are the same as in the Solar Tables, namely, in the first table, the fifth decimal figure of Argument I., and in the second table the seventh decimal figure of the logarithm of the radius vector. As a unit of the fifth decimal figure of Arg. I. corresponds to $0''.03$, and for eclipses we do not require seven decimals in the logarithm of the radius vector, the number of decimals employed in these tables will be sufficient. The numbers of these two tables are to be taken out with Arg. V. + Arg. XIII. of the Solar Tables + the day of the year.

As an example, I will calculate the position of the sun for the year −399, June 21^d 6^h Greenwich mean time, which is the time of the eclipse of Ennius, mentioned by Cicero.

In Paris mean time this date is,

$$= -400^y + 1^y + 172^d.25650$$
$$= -400^y + 1^y.470$$

and with these dates we find from the Solar Tables the following values of the Arguments, to which the day of the year has been added, where required,—

Digitized by Google

Arg. I	= 169·83726	Arg. V + XIII	= 188·320	Arg. X	= 36·47
— II	= 1369	— VI	= 37·49	— XI + XIII	= 5364
— III	= 37	— VII	= 32·93	— XII + XIII	= 454
— IV	= 32	— VIII	= 58·39	— XIII	= 197·900
		— IX	= 7·9	— XIV	= 206·39

From Tables IX. and X, of the Solar Tables, and from the first of the tables below we deduce the numbers,

$$117\cdot171\,;\ -5\cdot40\,;\ -0\cdot238\,;\ +0\cdot00002\,;$$

which must be multiplied by

$$-22\cdot49\,;\ (-22\cdot49)^2\,;\ (-22\cdot49)^3\,;\ (-22\cdot49)^4\,;$$

which gives,

	− 263518
	− 2731
	+ 2707
	+ 5
Sum =	− 263537

and from the other tables of the inequalities of Arg. I. we find the sum of the inequalities = 160; consequently

Arg. I + its inequalities = 167·21790

by means of which Table XXXIV. gives

The apparent tropical longitude = 83° 45′ 49″·9

Next, from Tables XX. and XXI. of the Solar Tables, and from the second table below, we get the numbers

$$-0\cdot421\,;\ +1\cdot11\,;\ +0\cdot014\,;\ -0\cdot00005\,;$$

which must be multiplied by the same numbers which we have just mentioned; whence we have

	+ 945
	+ 561
	− 159
	− 13
Sum +	1334

And from the other tables we obtain the sum of the other inequalities of the logarithm of the radius vector = 634. Now, as Table XXXV. gives 0·0068721 for the principal term of this logarithm we shall have, by the addition of the inequalities which we have just calculated,—

Log. radius vector = 0·0070689.

We can verify this result by computing directly the sidereal longitudes and the logarithm of the radius vector, and then adding

Digitized by Google

the precession and aberration. As, from the beginning of the year 1800 to the beginning of the year 1850 there are 50 Julian years less by 0·5 days, and the difference of the calendar in this century is 12 days, we have for the epoch of the tables,

$$1850^y - 12^d{\cdot}5.$$

In the next place, as year -399 is the first after the preceding bissextile, we must deduct $0^d{\cdot}25$ from the given time, which consequently becomes

$$-399^y + 172^d{\cdot}00650.$$

The difference between these two times is

$$-2249^y + 184^d{\cdot}50650;$$

for which we must compute the sidereal movement. Now as the Solar Tables give for the Julian year this movement $=360^\circ - 22''{\cdot}56009$, we find for the above interval of time

$$195^\circ\ 56'\ 42''{\cdot}4;$$

by adding to which $c'' = -33'\ 46''{\cdot}3$, we get

$$g'' = 195^\circ\ 22'\ 56''{\cdot}1;$$

and with this value of g'' we find the secular variations of the expressions for $n''\,t''$, and w'', given in the Solar Tables,

$$= +\,0''{\cdot}41114\,(t - 1850) - 0''{\cdot}04390\left(\frac{t-1850}{100}\right)^2$$

$$\text{and} = -\,0\cdot6726\ \ (t - 1850) - 1\cdot684\ \ \left(\frac{t-1850}{100}\right)^2$$

where $t - 1850 = -2248{\cdot}5$. Computing these, we find the secular variations of $n''\,t'' = -15'\ 46''{\cdot}7$; and as the sum of the constants added in the Solar Tables to the other inequalities of Arg. I. is $=1791$, the sum of the inequalities found above becomes $= -6''{\cdot}7$, after conversion into seconds. By adding these two numbers to the value of g'', we have

$$n''\,t'' = 195^\circ\ 7'\ 2''{\cdot}7;$$

and with this value we find the equation of the centre

$$= -\,29'\ 28''{\cdot}6.$$

Now, as the longitude of the perigee $=280^\circ\ 21'\ 41''{\cdot}0$, by adding these numbers to the value of $n''\,t''$, we find the sidereal longitude $=114^\circ\ 59'\ 15''{\cdot}1$.

Next, Tables XLI. and XLII. give the precession $= -31^\circ\ 13'\ 5''{\cdot}5$, and Table XLV. gives the aberration $=19''{\cdot}9$; consequently the apparent tropical longitude $=83^\circ\ 45'\ 49''{\cdot}7$, which differs from the longitude previously found by the table by only $0''{\cdot}2$.

With the same value of $n''\,t''$ we find the principal term of the log. radius vector, less by the sum of the constants added to the tables of its inequalities, $=0{\cdot}0069409$. After having performed

Digitized by Google

the multiplications, the secular inequalities mentioned above become +661, and the other inequalities computed above were =634; whence

Log. radius vector = 0·0070704,

and the difference from the value found previously from the tables is 0·0000015, which is sufficient for our purpose.

Table I. — *Inégalités de l'Arg. I. des Tables du Soleil.*

Arg. V. + Arg. XIII. + le Jour de l'Année.

Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$	Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$
0	+0·209		−0·00004	192	−0·240		+0·00003
8	+0·216	+ 7	−0·00004	200	−0·241	− 1	+0·00004
16	+0·219	+ 3	−0·00003	208	−0·238	+ 3	+0·00006
24	+0·217	− 2	−0·00002	216	−0·231	7	+0·00007
32	+0·211	6	−0·00002	224	−0·220	11	+0·00008
40	+0·200	11	−0·00001	232	−0·205	15	+0·00009
48	+0·186	14	−0·00001	240	−0·186	19	+0·00009
56	+0·167	19	−0·00001	248	−0·164	22	+0·00008
64	+0·145	22	−0·00001	256	−0·140	24	+0·00008
72	+0·120	25	−0·00002	264	−0·113	27	+0·00007
80	+0·092	28	−0·00003	272	−0·085	28	+0·00005
88	+0·062	30	−0·00003	280	−0·055	30	+0·00004
96	+0·031	31	−0·00004	288	−0·024	31	+0·00002
104	−0·001	32	−0·00005	296	+0·007	31	+0·00001
112	−0·033	32	−0·00006	304	+0·038	31	−0·00001
120	−0·065	32	−0·00007	312	+0·068	30	−0·00002
128	−0·095	30	−0·00007	320	+0·097	29	−0·00003
136	−0·124	29	−0·00007	328	+0·124	27	−0·00004
144	−0·150	26	−0·00006	336	+0·148	24	−0·00005
152	−0·174	24	−0·00005	344	+0·169	21	−0·00005
160	−0·195	21	−0·00004	352	+0·187	18	−0·00005
168	−0·212	17	−0·00002	360	+0·201	14	−0·00004
176	−0·225	13	−0·00001	368	+0·212	11	−0·00004
184	−0·235	10	+0·00001	376	+0·218	6	−0·00003
192	−0·240	− 5	+0·00003	384	+0·219	+ 1	−0·00003

Digitized by Google

Table II.—*Inégalités du Logarithme du Rayon Vecteur du Soleil.*

Arg. V. + Arg. XIII. + le Jour de l'Année.

Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$	Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)$
0	−0·026		−0·00002	192	+0·009		−0·00005
8	−0·014	+ 12	−0·00002	200	−0·003	− 12	−0·00004
16	−0·001	13	−0·00002	208	−0·014	11	−0·00004
24	+0·011	12	−0·00002	216	−0·025	11	−0·00004
32	+0·023	12	−0·00002	224	−0·035	10	−0·00003
40	+0·035	12	−0·00002	232	−0·045	10	−0·00002
48	+0·046	11	−0·00002	240	−0·055	10	−0·00002
56	+0·055	9	−0·00002	248	−0·063	8	−0·00001
64	+0·064	9	−0·00002	256	−0·070	7	0·00000
72	+0·072	8	−0·00002	264	−0·076	6	0·00000
80	+0·078	6	−0·00001	272	−0·081	5	+0·00001
88	+0·082	4	−0·00001	280	−0·084	3	+0·00001
96	+0·085	3	−0·00001	288	−0·086	− 2	+0·00001
104	+0·086	+ 1	−0·00002	296	−0·086	0	+0·00001
112	+0·085	− 1	−0·00002	304	−0·085	+ 1	+0·00001
120	+0·083	2	−0·00002	312	−0·082	3	+0·00001
128	+0·079	4	−0·00002	320	−0·077	5	+0·00001
136	+0·074	5	−0·00003	328	−0·071	6	0·00000
144	+0·067	7	−0·00003	336	−0·063	8	0·00000
152	+0·059	8	−0·00004	344	−0·054	9	−0·00001
160	+0·051	8	−0·00004	352	−0·044	10	−0·00001
168	+0·041	10	−0·00005	360	−0·033	11	−0·00002
176	+0·031	10	−0·00005	368	−0·022	11	−0·00002
184	+0·020	11	−0·00005	376	−0·010	12	−0·00002
192	+0·009	−11	−0·00005	384	+0·003	+13	−0·00002

On a Numerical Solution of Kepler's Problem, reduced to a Tabular Form. By Dr. A. De Gasparis.

(*Extracted from Letters addressed to Mr. Hind.*)

"I have constructed a numerical table for the solution of Kepler's problem. This table, which extends to 23 pages, similar

Digitized by Google

in size to those of Callet, gives, by simple inspection, the value of the excentric anomaly within about a degree, for any excentricity less than unity. By proportional parts we get the value of our unknown quantity to a fraction of a minute, and then by a calculation of the correction $\Delta\epsilon$ by the formula

$$\Delta\epsilon = \frac{M - \epsilon + e \sin \epsilon}{1 - e \cos \epsilon}$$

we get it within a fraction of a second.

"The table, consequently, contains all possible solutions of the equation

$$M = \epsilon - e \cdot \sin \epsilon$$

for whole-degree values of M and ϵ, and for values of e less than 1. It would not be difficult to obtain these solutions directly, but the calculation would be long, and there is the objection that we cannot beforehand estimate its extent. Allow me to explain the process I have followed.

"I remarked that if we wish to solve practically (say by a mechanical process) the equation

$$m = x \pm n \cdot \varphi(x)$$

in which the function φ is one of those which has been tabulated, we must mark on a rule the logarithms of the numbers c_1, c_2, c_3, &c., found by the equations

$$h = c_1 \varphi(h) = c_2 \varphi(2h) = c_3 \varphi(3h), \text{ &c.}$$

and place above them the numbers h, $2h$, $3h$, &c. The number h is arbitrary. This done, we must mark on another rule either from right to left, or from left to right, the logarithms of the numbers 0, 1, 2, 3, &c. If, now, we want to find the roots of the equation

$$m = x \pm n \varphi(x)$$

we must find on the first rule a number ph nearly equal to m; place it beneath the $-\infty$ of the second rule, and take at sight the sums of the logarithms of c_n of the first rule and the corresponding logarithms of the natural numbers on the second rule. The sum which gives the logarithm of n will be found at the part of the rule under the number qh; and this number will be the approximate root. We may correct this value by the proportions which are found of themselves by placing the symbol $-\infty$ first under the number next less than m, and, secondly, under the number next greater than m.

"In the case of Kepler's problem, I have taken $h = 1°$. I have then deduced the solutions which I wanted by the simple addition of the logarithms which are found at corresponding points on the two rules; and I have stopped the calculations in all cases where the logarithm of the sum exceeded zero.

"The following table is equivalent to two-fifths of the twenty-three pages of which the whole table is composed. In the example

Digitized by Google

subjoined, after the calculation of proportional parts, I find the correction by means of the formula $\Delta s = \frac{M - s + e \sin s}{1 - e \cos s}$.

Specimen of Table.

M	e	s	M	e	s	M	e	s	M	e	s
°		°	°		°	°		°	°		°
26	0·36054	39	26	0·80389	69	27	0·40946	43	27	0·83954	73
26	0·38014	40	26	0·81723	70	27	0·42713	44	27	0·85536	74
26	0·39905	41	26	0·83066	71	27	0·44429	45	27	0·86731	75
26	0·41734	42	26	0·84417	72	27	0·46100	46	27	0·88139	76
26	0·43506	43	26	0·85779	73	27	0·47729	47	27	0·89562	77
26	0·45225	44	26	0·87152	74	27	0·49320	48	27	0·91001	78
26	0·46897	45	26	0·88538	75	27	0·50877	49	27	0·92456	79
26	0·48526	46	26	0·89938	76	27	0·52403	50	27	0·93930	80
26	0·50115	47	26	0·91353	77	27	0·53900	51	27	0·95423	81
26	0·51669	48	26	0·92785	78	27	0·55372	52	27	0·96937	82
26	0·53189	49	26	0·94234	79	27	0·56820	53	27	0·98473	83
26	0·54681	50	26	0·95702	80	27	0·58248	54	27	1·00032	84
26	0·56146	51	26	0·97190	81	27	0·59658	55	28	0·03600	29
26	0·57586	52	26	0·98699	82	27	0·61052	56	28	0·06981	30
26	0·59006	53	26	1·00231	83	27	0·62432	57	28	0·10166	31
26	0·60406	54	27	0·03718	28	27	0·63800	58	28	0·13174	32
26	0·61789	55	27	0·07200	29	27	0·65157	59	28	0·16023	33
26	0·63158	56	27	0·10472	30	27	0·66506	60	28	0·18727	34
26	0·64513	57	27	0·13555	31	27	0·67848	61	28	0·21300	35
26	0·65858	58	27	0·16468	32	27	0·69185	62	28	0·23755	36
26	0·67193	59	27	0·19227	33	27	0·70518	63	28	0·26101	37
26	0·68521	60	27	0·21848	34	27	0·71849	64	28	0·28349	38
26	0·69844	61	27	0·24343	35	27	0·73179	65	28	0·30507	39
26	0·71162	62	27	0·26724	36	27	0·74510	66	28	0·32583	40
26	0·72477	63	27	0·29001	37	27	0·75842	67	28	0·34584	41
26	0·73791	64	27	0·31184	38	27	0·77178	68	28	0·36517	42
26	0·75105	65	27	0·33280	39	27	0·78519	69	28	0·38387	43
26	0·76420	66	27	0·35298	40	27	0·79866	70	28	0·40200	44
26	0·77739	67	27	0·37245	41	27	0·81220	71	28	0·41961	45
26	0·79061	68	27	0·39125	42	27	0·82582	72	28	0·43673	46

Example.—Let the equation be $26°·35794 = s - 0·82575 \sin s$.

For $M = 26°$, and by variation of e we find $s = 70°·63440$.

For $M = 27°$, and by variation of e we find $s = 71°·99486$.

Digitized by Google

Whence for M = 26°·35794, we shall have ε = 71°·12136.

The error is 0°·003. The correction $\Delta\varepsilon$ comes out + 0·00472."

Whence, lastly, ε = 71°·12608. Error = 0°·000003.

An Expeditious Method of finding the Latitude by simply observing the Azimuthal Angles of two Circumpolar Stars with a Theodolite. By M. Babinet.

(*Communicated by Admiral W. H. Smyth.*)

It is presumed that the method is designed to meet the case of a traveller, who, from other considerations, has been led to take with him a small theodolite and pocket-chronometer, to the exclusion of a sextant or repeating circle; and that he has with him a catalogue of the brighter stars. Regarded otherwise, the method would be much inferior to others already known.

In the well-known triangle Z P S, let Z be the zenith, P the pole, and S the place of a circumpolar star. $ZP = 90 - \lambda$. $PS = \delta$. $PZS = A$, the azimuth of the star.

Then

$$\sin A \cdot \cos\lambda = \sin\delta \cdot \sin PSZ$$

It is proposed that the star's azimuth shall be observed when at its greatest elongation, in which case $PSZ = 90°$, and the above equation becomes

$$\sin A \cdot \cos\lambda = \sin\delta \qquad (1)$$

Similarly for the second star we should have

$$\sin A' \cdot \cos\lambda = \sin\delta' \qquad (2)$$

Dividing (1) − (2) by (1) + (2), we then have

$$\frac{\tan\frac{1}{2}(A-A')}{\tan\frac{1}{2}(A+A')} = \frac{\tan\frac{1}{2}(\delta-\delta')}{\tan\frac{1}{2}(\delta+\delta')} \qquad (3)$$

When the two stars are observed at opposite elongations, A and A′ will have opposite signs, and A + A′ will be found at once from the difference of the two readings of the horizontal circle, half the difference will be

$$\tfrac{1}{2}(A + A')$$

By equation (3) we thence get

$$\tfrac{1}{2}(A - A')$$

Thence A and A′ separately, and by either (1) or (2) the required latitude λ.

Having found from A or A′ the azimuthal reading of the pole, we can then set the telescope in the meridian, and obtain the time very nearly by a transit of an intertropical star. The whole operation need not take more than twenty minutes, if the stars are previously suitably selected.

Digitized by Google

M. Babinet gives the following example for a place, the latitude of which is 51° 49′ north. Suppose the theodolite levelled, and the reading of the horizontal circle for the azimuth of the pole to be 67° (unknown); suppose, further, the two stars selected to be

	R.A.	N.P.D.
ε Cassiopeæ	1h 44m	27° 3′
and		
α Urs. Maj.	8 18	28 48

and the observation to be made on the 1st of March, 1857.

A rough preliminary calculation by the relation

$$\cos A = \tan \delta \,.\, \tan \lambda$$

made with a guessed value of λ will show that ε *Cassiopeæ* will attain its greatest east elongation at about $6^h\ 24^m$ after noon, and α *Urs. Maj.* its greatest west elongation at about $6^h\ 37^m$, the second observation following the first in about 13 minutes.

The horizontal circle-readings will be respectively for ε *Cassiopeæ* 114° 21′·2; for α *Urs. Maj.* 15° 48′·1; whence we find

$$\tfrac{1}{2}(A+A') = +49^\circ\ 16'.6$$

and by (3),

$$\tfrac{1}{2}(A-A') = -\ 1\ 55.0$$

$$A = 47\ 21.6 \text{ East}$$

$$A' = 51\ 11.6 \text{ West}$$

and by either (1) or (2),

$$\lambda = 51\ 49$$

To ascertain how the result would be affected by errors of observation, differentiate the equations (1) and (3), and it will be found that

$$d\lambda = \cot\lambda \,.\, \frac{\cos A \,.\, \cos A'}{\sin (A + A')} \,.\, d(A + A');$$

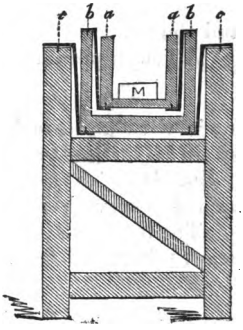
whence we may conclude that for such a pair of stars as the above, the error of the resulting latitude will scarcely exceed one-third of the error of the observed difference of azimuths.

At the conclusion of the ordinary business of the meeting, the Astronomer Royal exhibited and explained a model of the stand now in use at the Royal Observatory for the support of the mercury vessel of the reflex-zenith-tube. Considerable difficulty had been experienced, as is well known, in the use of this instrument on its first establishment, from the constant presence of tremor, and it was twice taken down and remounted in new positions, with little, if any, relief from the annoyance sought to be avoided. Indeed, the continual agitation of the artificial horizon seemed to testify to a never-ceasing palpitation of the soil of the Greenwich hill. After alluding to the expedients which were previously and vainly resorted to, and which are recounted in the Annual Reports

Digitized by Google

to the Board of Visitors, the Astronomer Royal turned to the model, and remarked that, at first sight, perhaps nothing could look more unpromising than the arrangement before his audience, the parts of which admitted of free motion in every direction, and seemed directly and intentionally opposed to the ideas of fixity and permanence.

The mercury vessel M rests on the bottom of a wooden frame *a a*, supported by broad bands of vulcanised caoutchouc attached to a second frame *b b*, which is itself similarly connected with a very solid stand *c c*. The vertical tremors were found to be entirely annihilated by this mode of suspension, and there remained only a slight horizontal swimming of the image which was at once cut off by connecting frames *a* and *c* horizontally by two fine shreds of the same elastic material. The vibrations of the soil are thus spent upon the elastic parts of the apparatus, and the inertia of the supported parts allowed to have free and beneficial action.



The subject has been already touched upon in the Annual Report, but the woodcut may make the explanation of the arrangement a little clearer.

Mr. William Taylor, in a letter to one of the Secretaries, says that he has found an artificial horizon of pitch a very convenient one under certain circumstances, such as when a reflexion observation has to be obtained in a situation much exposed to wind. He recommends heating the pitch in a flat pan, filtering it through muslin, and conveying the pan, with the pitch still in a thoroughly fluid state, to the support on which it is intended to rest, leaving it to cool with a cover over it. He remarks that a perfectly horizontal surface is thus obtained, a fact we should be much inclined to doubt, where the vessel and support have thus been greatly heated and cooled.

Two New Comets.

A comet was discovered by Professor D'Arrest at Leipsic on the 22d of February, in the following position,—

1857, Feb. 22. $16^h\ 40^m$ Leipsic M.T., R.A. 320° 37′ N.P.D. 67° 56′

The following two positions have been obtained at Redhill,—

1857	G.M.T. h m s	App. R.A. h m s	App. N.P.D. ° ′ ″	Comps.	Stars.
Feb. 28	17 23 32	21 43 28·9	63 5 27	3	*a*, *b*,
March 23	9 24 1	0 37 58·0	44 8 38	3	*c*, *d*.

Digitized by Google

Assumed mean places of stars, 1857·0.

		h m s	° ′ ″
a	Lal. 42416 and Bessel	21 37 30·00	62 48 24·0
b	— 42436 and Bessel	21 38 56·10	63 39 25·0
c	— 1222 and Rümker	0 38 40·10	43 53 19·0
d	— 1314 and Oeltzen	0 41 31·50	44 16 15·0

Elements computed by Dr. Donati of Florence were forwarded by Mr. Drach. The most reliable up to the present time are, however, those of Mr. Pape of Altona, viz.

T	March 21·39349	Berlin M.T.
π	74 49 11·4	M. Eq. 1857·0
Ω	313 12 58·2	
i	87 57 6·7	
Log. *q*	9·887693	Motion direct.

From these are deduced the following approximate positions for April, at Berlin midnight:—

	R.A. h m s	N.P.D. ° ′		R.A. h m s	N.P.D. ° ′
April 3	3 1 56	46 10	April 9	4 3 20	51 31
4	13 26	46 55	10	11 54	52 32
5	24 24	47 45	11	20 0	53 34
6	34 52	48 38	12	27 40	54 35
7	44 52	49 33	13	34 56	55 37
8	3 54 20	50 31	14	4 41 48	56 40

A second comet was discovered by Dr. Bruhns at Berlin, on the 18th of March. Dr. Bruhns and Dr. Forster found as its position—

Berlin M.T.	R.A.	N.P.D.
March 18^d 8^h 28^m 30^s·6	30° 49′ 54″·3	81° 40′ 30″·0

Both this and the comet of D'Arrest were comparatively bright at the time of discovery. No English observations have yet reached the Editor, from the unfavourable state of the weather the last week.

Dr. Bruhns has computed elements from Berlin observations on March 18, 19, and 20; which, as Mr. Pape has pointed out, bear a general resemblance to those of the third comet of 1846, as calculated by Dr. Van Galen for the present year.

Comet II. 1857. Dr. Bruhns.			Comet III. 1846. Dr. Van Galen.	
T	March 24·9877 B.M.T.		T	1857, June 25·77224 G.M.T.
π	119 36 34·3	App. Eq.	π	115 35 11·93 M. Eq.
Ω	116 10 50·4		Ω	101 54 2·67 June 25.
i	24 8 23·5		*i*	30 6 37·28
Log. *q*	9·759140		φ	53 35 31·93
	Motion direct.		*n*	627″·1483
			Log. *a*	0·5017575

Digitized by Google

The third comet of 1846 was expected to return to perihelion in November 1851, but though sought for on all available opportunities at Cambridge and elsewhere, was not re-discovered in that year. A second return was fixed, as above, by Dr. Van Galen, for the end of June in the present year. The Editor fears that the readers of the *Monthly Notices* must be content to suspend their opinion on the possibility of the two orbits above given being reconcileable, until the new comet has been sufficiently observed for the computer to ascertain whether its elements are also elliptic. Not many days will be required for this purpose.

Mr. Bruhns has calculated the following Ephemeris for Berlin midnight from his parabolic elements :—

	R.A.	N.P.D.		R.A.	N.P.D.
	h m s	° ′		h m s	° ′
April 3	3 0 26	62 11	April 9	3 25 16	52 59
4	4 17	60 44	10	30 0	51 22
5	8 13	59 14	11	34 59	49 42
6	12 15	57 43	12	40 15	48 2
7	16 25	56 10	13	45 50	46 20
8	3 20 45	54 36	14	3 51 45	44 37

The comet will be visible throughout the month of May.

ERRATA.

Vol. XVI. No. 6, page 155, *Thetis*, 1856, March 11, M.S.T. of Observation, *for* $14^h 22^m 35^s.4$, *read* $14^h 22^m 45^s.4$; Apparent R.A., *for* $13^h 42^m 16^s.29$, *read* $13^h 42^m 26^s.29$.

Vol. XVII. page 36, line 11, *for* weight of tube, *read* weight of tube per square foot.

CONTENTS.

	Page
Fellows elected	135
Observations of small Planets at the Royal Observatory	ib.
Occultation of *Jupiter*. Professor Challis and Mr. Breen	136
Rev. W. R. Dawes, on two Occultations	141
Mr. Hippisley. Experimental Illustration of Projection	142
Mr. Lassell and the Astronomer Royal on same subject	ib.
Rev. Baden Powell. On Optical Phenomena in Occultations	143
G. C. Bompas, Esq. On the Horary Variation of Meteors	147
Extract of a Letter from Professor Argelander	148
Hansen. Supplement to Solar Tables	150
Dr. De Gasparis. Numerical Solution of Kepler's Problem	155
M. Babinet. An Expeditious Method of Finding the Latitude	158
Astronomer Royal. Support of Mercury-vessel for the Zenith-Sector ...	159
Two New Comets	161

London :—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, April 7, 1857.

Digitized by Google

R. A. S. Monthly Notices.

Appendix to No. 5, Vol. XVII.

The receipt of No. 1076 of the *Astronomische Nachrichten* enables the Editor to supply the additional and interesting intelligence that the comet of Dr. Bruhns proves to be identical with that of Brorsen, as suspected by Mr. Pape. An independent computation of approximate elliptic elements from observations made on March 18, 20, and 24, led at once to the adoption of a considerable angle of eccentricity, and justified Mr. Pape in assuming that a modification of the elements of Van Galen of admissible (though of unexpected) amount would suffice for the representation of the observations of the present year. He has thus found—

$$T = \text{March } 29{\cdot}22503 \text{ Berlin M.T.}$$
$$\left.\begin{aligned} \pi &= 115\ 52\ 15{\cdot}6 \\ \Omega &= 101\ 59\ 30{\cdot}8 \end{aligned}\right\} \text{M. Eq. } 1857{\cdot}0$$
$$i = 29\ 42\ 46{\cdot}7$$
$$\varphi = 53\ 21\ 0{\cdot}0$$
$$\text{Log } a = 0{\cdot}496045$$

from which he has computed the following short Ephemeris for immediate use :—

For Berlin Midnight.

1857	R.A. h m s	N.P.D. ° ′	1857	R.A. h m s	N.P.D. ° ′
April 1	2 54 38	66 4·1	April 9	3 24 54	56 16·9
2	2 58 2	64 53·8	10	3 29 23	55 0·7
3	3 1 32	63 42·5	11	3 34 7	53 44·2
4	3 5 8	62 30·4	12	3 39 9	52 27·4
5	3 8 50	61 17·3	13	3 44 29	51 10·2
6	3 12 38	60 3·4	14	3 50 9	49 52·8
7	3 16 34	58 48·6	15	3 56 9	48 35·3
8	3 20 38	57 33·1	16	4 2 29	47 17·7

A more extended Ephemeris will be supplied shortly.

R. C. C.

Digitized by Google

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *April* 8, 1857. No. 6.

Rev. BADEN POWELL, V.P., in the Chair.

For Notice of a newly-discovered Planet, see page 169.

Volume XXV. of the *Memoirs* has recently been published. The price is 5*s*. to Fellows of the Society, and 10*s*. to the public. The sixteenth volume of the *Monthly Notices*, containing the shorter papers, abstracts of memoirs, and notices of discovery and new publications, is given to purchasers of the 4to. volume. The two publications are supplementary to each other, and are to be considered as parts of the same series. Between them they contain a complete account of the proceedings of the Society during the year.

The Editor wishes to call the attention of the usual contributors to the *Monthly Notices* to a few particulars in which they might materially lighten his labours without (it is hoped) imposing any troublesome constraint on themselves as writers of papers. At the present time numerous communications are sent without date, or signature, or any express intimation that they are intended for publication. The papers come to hand also of all sizes and shapes, rendering their arrangement, whether immediately for the press, or afterwards for preservation, difficult.

Digitized by Google

Diagrams, again, are often given either on too large a scale to serve as the copy for the engraver, or on too small a scale for him to be able to perceive what peculiarity he is to make clear. For instance, as when a circular arc is distorted slightly into a hyperbolic one; or when a shadow has some peculiarity of outline. Tables are also frequently sent so arranged as not to come within the limits of the page, when a very little ingenuity or an arrangement in three longer columns instead of four shorter ones, would save the necessity of copying them. The present Editor is no admirer of pedantic rules, or of requirements that signatures shall follow precisely at so many inches and tenths of an inch from the previous line; neither has he any wish to shift the ordinary and proper labour of editing on to the contributor; but a very little acquaintance with public correspondence, or with what is due to a learned Society, will, it is believed, make the following recommendations appear reasonable:—

1. That all papers intended for publication be dated, and headed "For the *Monthly Notices*," and that space be left above the body of the paper for Editor's heading.

2. That they be written in black ink, and on foolscap paper (13 × 8 inches), ruled with *about* three lines to the inch, with a margin of *about* an inch next the crease.

3. That papers in foreign languages, *when communicated through a resident Fellow*, be accompanied by an arranged translation.

4. That tables be arranged, as nearly as may be practicable, to suit the ordinary size of page; and that, when a diagram is required, one be given on a scale suited to the page, and a second (if required) on any larger scale, as large as may be necessary to elucidate the peculiarity to be represented.

5. That where optical or physical phenomena have been observed, the description of telescope, the aperture, focal length, ratio of aperture to focal length, and magnifying power, be stated in all cases.

A practicable degree of compliance with the above suggestions will, in addition to other advantages, lessen the time required for preparing and issuing successive numbers.

It has been already recommended that when regular and lengthened series of observations of planets or comets have been obtained, such series be sent for publication to Altona; but it is by no means intended to exclude from this periodical casual observations, moderate in number, or possessing immediate interest; as, for instance, the early observations of a newly-discovered body, occultations, or other phenomena.

From time to time Fellows of the Society send descriptions of new private observatories, not always accompanied or even followed by observations of value, and frequently insisting in the main on the lowness of the outlay, or the ease with which the

Digitized by Google

Observatory may be taken to pieces, as the motive for making the communication. Desirable as may be the increase in the number of such private establishments, each in its own locality fostering an interest in the branch of knowledge which this Society represents, it must be borne in mind that the only sufficient object of such a public statement is the enabling another person to judge of the relative sufficiency of the means used in procuring observations already published, or about to be published; and it will be at once perceived that such communications should be concise and to the point. Where some detail of construction is to be explained, an architect's plan and elevation with running notes is what is rather wanted, and will in that case be duly acknowledged, and deposited in the archives of the Society for the future consultation of any one about to build. Descriptions of a new eye-piece, a new material, or process of manufacture, a successful experiment or the like, do not, of course, come within the scope of the preceding remarks.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Month of March, 1857.

(*Communicated by the Astronomer Royal.*)

Parthenope.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Mar. 4	11 30 58·1	10 21 37·94	75 40 38·84
9	11 7 1·6	10 17 20·28	75 11 26·66
13	10 48 6·1	10 14 7·85	74 50 28·67
16	10 34 5·0	10 11 54·10	74 36 16·22
20	10 15 39·9	10 9 12·18	74 19 31·30

Fides.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Mar. 4	11 56 46·1	10 47 30·12	79 51 11·18
13	11 13 29·4	10 39 35·29	79 16 30·06
16	10 59 17·2	10 37 10·46	79 6 45·95
20	10 40 35·2	10 34 11·62	78 55 23·71
23	10 26 46·0	10 32 9·82	78 48 12·77

Digitized by Google

Hebe.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Mar. 13 10 0 33·1	9 26 27·09	70 16 11·31
20 9 29 59·5	9 23 24·31	69 39 37·62
23 9 17 17·3	9 22 29·65	69 26 47·16

Psyche.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Mar. 4 11 15 43·8	10 6 21·08	78 3 11·87
13 10 34 13·6	10 0 13·09	77 23 13·41
16 10 20 38·4	9 58 25·32	.....
20 10 2 45·8	9 56 15·95	76 57 23·17

Proserpine.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Mar. 4 12 46 56·0	11 37 48·25	82 14 17·75
13 12 3 42·1	11 29 56·23	81 30 14·08
16 11 49 15·5	11 27 16·95	81 16 36·15

Iris.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Mar. 20 14 3 23·0	13 57 32·69	109 2 40·90

*Mr. Pogson's New Planet.**

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Apr. 17 11 44 15·4	13 28 25·77	105 30 7·58
18 11 39 20·2	13 27 26·32	105 23 11·07
20 11 29 30·7	13 25 28·32	105 9 4·24
23 11 14 49·3	13 22 34·20	105 47 19·04

* The observations of N.P.D. have *not* been corrected for parallax.

Digitized by Google

On a Variable Star. By the Astronomer Royal.

The Astronomer Royal desires to draw the attention of the Society to the star B.A.C. 3345, of which the variability seems to be very great. In the last year, 1856, several attempts were made to observe it, amongst other moon-culminating stars set down in the *Nautical Almanac* for 1859, but in every instance without success. In its stead, 19 *Leonis*, which precedes it by a few seconds of time, was observed four times; and a star which precedes 19 *Leonis* by ten seconds was observed twice, while nothing whatever was visible at the exact position of the star sought for. The observers reported the circumstance, and were directed to keep a vigorous watch for the missing star.

This year no difficulty has been found in observing it, four observations having been already made of it. On April 11 it was observed by Mr. Criswick, who remarks that it is the second of two stars visible in the field, and of a blood-red colour compared with the other star. Mr. Dunkin, who observed it on April 17, remarks that its colour was very red. These observers consider its magnitude at the times of observation to be the 7th.

The star is identical with Lalande 19197, who marks it as of the 9th magnitude. In Mayer's Catalogue, as revised by Mr. Baily (*Mem. R. A. S.* vol. iv.), it is No. 420.

It is also identical with Piazzi IX. 176, and is marked of the 8th magnitude. In Taylor's Madras Catalogue it is marked of the 7th magnitude. Finally, in Argelander's *Uranometria Nova* it is called variable.

The statement here given will, it is hoped, induce astronomers to watch the star during the present season, before it approaches too closely to conjunction with the sun.

Discovery of another Small Planet.

Another member, the forty-third, of the group of small planets circulating between *Mars* and *Jupiter*, was discovered at Oxford on the 15th of April by Mr. Norman Pogson, in comparing with the heavens one of his MSS. charts. The following are Mr. Pogson's first observations,—

1857.	G.M.T.	App. R.A.	App. N.P.D.
	h m s	h m s	° ′ ″
April 15	13 34 14	13 30 19·96	105 43 2·5
	13 57 12	30 18·98	42 56·7
	15 24 31	30 15·26	42 36·3

Intelligence was circulated throughout the country on the two following days; and observations from Greenwich, Cambridge, and

Digitized by Google

Liverpool, will be found in the present Number. So far as we have heard at present, Mr. Pogson has no one to share his honours with him on the present occasion.

Observations.

LIVERPOOL. Equatorial. (Mr. Hartnup.)

1857.	G.M.T.	R.A.	Log $\frac{p}{P}$	N.P.D.	Log $\frac{q}{P}$
	h m s	h m s		° ′ ″	
April 18	9 54 35·7	13 27 30·64	−8·305	105 23 40·7	−9·9584
	10 14 32·4	29·79	−8·230	34·9	−9·9614
	10 34 28·9	28·98	−8·134	30·0	−9·9638
19	9 46 40·3	13 26 31·63	−8·315	105 16 43·4	−9·9577
	9 58 38·3	31·23	−8·273	39·6	−9·9596
	10 10 36·2	30·75	−8·225	36·1	−9·9613
20	9 41 45·5	13 25 32·69	−8·315	105 9 38·3	−9·9574
	9 53 43·3	32·21	−8·273	35·6	−9·9592
	10 5 41·2	31·82	−8·225	30·4	−9·9610

The observations are corrected for refraction.

The following is the assumed mean place of the Star of Comparison for Jan. 0·1857, deduced from the Greenwich and Edinburgh Observations :—

B. A. C. 4494. R.A. 13 h 19 m 49·78 s. N.P.D. 105 ° 13 ′ 51·64 ″.

CAMBRIDGE. Equatorial. (Prof. Challis.)

1857.	G.M.T.	R.A.	$p \times \Delta$	N.P.D.	$q \times \Delta$	No. of Comp.	Star.
	h m s	h m s	s	° ′ ″	″		
April 17	10 37 31·6	13 28 29·26	−0·104	105 30 5·4	−7·85	8	*q*
18	10 25 34·9	13 27 30·04	−0·115	105 23 14·8	−7·83	8	*q*

The star (*q*) is H.C. 25079 and 25080, and its assumed mean place 1857·0 is R.A. = $13^h\ 26^m\ 59^s{\cdot}93$, N.P.D. = 105° 35′ 9″·6 as given by the Catalogue.

Observations of Comet I., 1857 (D'Arrest's).

CAMBRIDGE. Equatorial. (Prof. Challis.)

1857.	G.M.T.	R.A.	$p \times \Delta$	N.P.D.	$q \times \Delta$	No. of Comp.	Star.
	h m s	h m s	s	° ′ ″	″		
March 4	16 43 34·1	22 1 0·09	−0·404	59 34 50·2	−6·12	8	*a*
28	8 13 40·5	1 43 18·20	+0·495	43 28 28·2	5·56	5	*b*
April 2	8 58 20·6	2 48 32·61	0·478	45 24 32·9	5·68	12	*c*
15	9 30 59·0	4 47 42·57	0·414	57 35 13·9	5·94	6	*d*
16	8 52 32·7	4 54 14·45	+0·410	58 34 59·0	−5·50	6	*e*

Digitized by Google

Assumed Apparent Places of the Stars.

	Apparent R.A.	Apparent N.P.D.	Authority.
	h m s	° ′ ″	h m s
a	21 59 48·39	59 34 41·4	Bessel Z. 327, 21 58 15
b	1 42 9·24	43 19 23·9	Argelander 2051
c	2 44 21·26	45 27 19·3	H.C. 5364
d	4 46 14·78	57 27 7·5	H.C. 9171
e	4 53 4·04	58 26 0·0	H.C. 9389

Passage of D'Arrest's Comet over a Fixed Star. Observed by R. Hodgson, Esq.

"At about 10^h mean time on the 3d of April, the comet of D'Arrest passed over a small star. Its appulse was not noticed, the telescope having been turned to another object; but upon returning to the comet, the small star was missed, and with power of 70 was not divisible from the nucleus. On changing to power 140, the small star was instantly visible, about midway between the nucleus and edge of the comet, *above* the centre (as seen in an inverting telescope). The star was of 7th magnitude, and was decidedly much brighter than the nucleus of the comet."

We learn through Dr. Gould's *Astronomical Journal* that the comet of Professor D'Arrest was also discovered independently at Newark in the United States, by Mr. Van Arsdale.

Observations of Comet II., 1857 (*Bruhns's*).

CAMBRIDGE. Equatorial. (Prof. Challis.)

1857.	G.M.T.	R.A.	$p \times \Delta$	N.P.D.	$q \times \Delta$	No. of Comp.	Star.
	h m s	h m s	s	° ′ ″	″		
March 23	8 9 34·3	2 20 50·43	+0·361	76 29 43·9	−6·53	1	*f*
April 7	8 47 37·0	3 17 38·15	0·405	58 53 14·9	6·19	14	*g*
8	9 16 36·6	3 21 54·89	0·399	57 36 38·7	6·47	10	*h*
9	8 21 5·1	3 26 4·44	0·421	56 24 13·8	5·72	8	*i*
11	8 43 53·9	3 35 6·52	0·431	.....	...	9	*k*
11	8 53 47·9	.....	...	53 50 58·8	5·98	2	*k*
15	8 49 51·7	3 54 49·80	0·462	48 47 28·6	5·55	6	*l*
16	8 24 13·2	4 0 7·96	0·475	47 33 19·0	5·04	6	*m*
17	8 33 31·9	4 5 45·94	0·485	46 17 24·0	5·07	8	*n*
18	8 22 20·8	4 11 33·84	0·496	45 3 22·2	4·75	7	*o*
20	8 36 6·0	4 24 5·53	+0·518	42 35 51·5	−4·70	8	*p*

Digitized by Google

Assumed Apparent Places of the Stars.

	Apparent R.A.	Apparent N.P.D.	Authority.
	h m s	° ′ ″	
f	2 23 8·40	76 40 41·1	Bessel II. 383
g	3 16 33·92	58 46 27·9	H.C. 6265
h	3 19 14·62	57 41 16·4	H.C. 6344
i	3 27 41·68	56 7 32·8	H.C. 6597
k	3 35 14·89	53 59 31·3	H.C. 6820
l	3 58 31·69	48 53 36·7	H.C. 7584
m	3 58 17·04	47 11 31·2	H.C. 7568 and 7569
n	4 7 59·71	46 40 7·2	H.C. 7915
o	4 10 38·80	44 52 40·8	H.C. 8015
p	4 25 41·91	42 56 26·6	H.C. 8553 and 8554

LIVERPOOL. Equatorial. (Mr. Hartnup.)

1857.	G.M.T.	R.A.	Log $\frac{p}{P}$	N.P.D.	Log $\frac{q}{P}$	Star.
	h m s	h m s		° ′ ″		
April 7	8 25 25·6	3 17 33·51	+8·668	58 54 20·5	−9·8352	(*a*)
	8 52 26·7	3 17 37·99	+8·665	58 53 2·8	−9·8577	
11	8 45 10·8	3 35 7·29	+8·693	53 51 33·8	−9·8279	(*b*)
	9 10 12·3	3 35 12·21	+8·685	53 50 15·1	−9·8536	
14	8 22 52·8	3 49 33·95	+8·715	50 4 54·9	−9·7790	(*c*)
	8 47 54·2	3 49 39·15	+8·715	50 3 37·1	−9·8079	
16	8 25 32·2	4 0 7·76	+8·732	47 33 29·4	−9·7616	(*d*)
	8 45 33·7	4 0 11·78	+8·732	47 32 23·9	−9·7870	

The observations are corrected for refraction. The corrections to be applied for parallax in time, and are represented by p and q. P is the equatorial horizontal parallax.

The following are the assumed mean places of the Stars of Comparison for 1857·0:—

Star.	R.A.	N.P.D.	Authority.
	h m s	° ′ ″	
(*a*) = B. A. C. 1138	3 35 21·61	58 10 6·21	Greenwich Observations.
(*b*) = ,, 1219	3 48 16·03	50 24 26·70	,, ,,
(*c*) = ,, 1291	4 5 9·91	49 53 1·75	British Association Cat.
(*d*) = ,, 1339	4 13 39·13	47 54 40·19	,, ,,

From the 7th to the 16th no perceptible difference was observed in the appearance of the comet. The nebulosity was round, and of about 1′ 40″ diameter. For about 15″ from the centre it was very bright.

Any doubt that might have been supposed to remain on the identity of the comet discovered by Dr. Bruhns with that of Brorsen in the year 1846, has been removed by an investigation by Dr. Bruhns, which has appeared recently in the *Astron. Nach.* Dr. Bruhns's Elements are given on the next page with the portion of his Ephemeris which is still available.

Digitized by Google

T = March 29^d·25384 Berlin M.T.

π = 115° 48′ 37″·0 } App. Eq. March 20·0
Ω = 101 53 7·9 }
i = 29 45 0·8
φ = 53 17 0·7
Log a = 0·494912

Ephemeris for Berlin Midnight.

1857.	R.A. h m s	N.P.D. ° ′	1857.	R.A. h m s	N.P.D. ° ′
May 1	6 3 8	30 43·8	May 17	9 47 14	28 48·0
2	15 12	29 56·9	18	59 30	29 25·1
3	27 51	29 14·3	19	10 11 11	30 5·7
4	41 3	28 36·2	20	22 16	30 49·4
5	6 54 45	28 3·3	21	32 46	31 36·1
6	7 8 53	27 35·5	22	42 42	32 25·1
7	23 24	27 13·3	23	10 52 5	33 16·4
8	38 13	26 56·9	24	11 0 58	34 9·4
9	7 53 13	26 46·6	25	9 21	35 3·8
10	8 8 17	26 42·2	26	17 14	35 59·3
11	23 18	26 43·6	27	24 40	36 56·0
12	38 10	26 50·8	28	31 40	37 53·5
13	8 52 48	27 4·0	29	38 18	38 51·6
14	9 7 4	27 22·6	30	44 35	39 50·1
15	20 57	27 46·2	31	50 33	40 48·6
16	9 34 22	28 14·9	June 1	11 56 14	41 46·8

Relative brightness, that at the time of discovery being taken for unity:—

April 6	...	1·70	May 12	...	1·01
18	...	1·72	24	...	0·70
30	...	1·45	June 1	...	0·50

From Letters of Captain Jacob to Mr. Grant.

"Feb. 13.—I have got a very good epoch for α *Centauri* for the beginning of this year, namely—

Year.	$\angle$ °	δ ′
1857·039	316·96	3·977

being the mean result of 15 days' observations. This is as close an accordance as could be expected with the predicted place as

Digitized by Google

given in page 124 of the *Monthly Notice* for March 1856, and indicates a path even more *convex* toward the centre than is there indicated. I have had some very fine views of *Saturn* lately; and I have been pretty assiduously observing the satellites (especially elongations of *Titan*) to try if I can improve the value of *Saturn's* mass: and I have numerous observations of *all* the other satellites except *Hyperion*, which I have not yet picked up. I have even six undoubted observations of *Mimas*. It was picked up quite accidentally, for I never thought of looking for it after reading Herschel's Cape experience, and after the difficulty I had myself found with *Enceladus;* but I took it once in the first instance by mistake for *Enceladus*, and afterwards picked it up without difficulty; indeed on a first-rate night, such as we get but rarely even here, it appears rather the brighter of the two. Such a night was the 21st January, when I got measures of *Enceladus* close to *Saturn's* pole, and when I saw the whole of the shaded portion of *Saturn's* southern hemisphere divided into minute belts almost as distinct as those of *Jupiter*, but almost infinitely more numerous. I can fully confirm the opinion expressed by Mr. John Watson in the *Monthly Notice* for April last as to the nature of the mark on the outer ring, viz., that it is not a *division*, but a mere belt or streak: it is not at all difficult to see here, indeed I cannot look at *Saturn*, when the atmosphere is at all fit for observing, without seeing it, even with powers as low as 170; it appears as a pale streak, about one-third or rather more of the width of the principal division, and not quite so dark in hue as the obscure ring as seen on the planet's face. But further, it is *my* opinion that the principal *division*, so called, is of the same character, viz., a belt or mark, and not a clear space or division; for I not only see it of a brown hue, but *can distinctly make out the shadow of the planet across it*, as already mentioned at page 126 of the *M. Not.* for March 1856. On the 1st January, when the planet was almost exactly in opposition, the projecting *ears* alluded to in the same page were seen one on each side, crossing the division, though no other part of the planet's shadow on the ring was visible."

"Feb. 28.—I have nearly completed my measures of the satellites for this season, and they ought to give a good value of the planet's mass, as I have good distance-measures of *Titan* at 10 elongations (5 E and 5 W); and also a large number of pretty good measures, both in angle and distance, of all the five *old* satellites, on which it may perhaps be possible to build a *theory*, and to approximate at least to the mass of the ring. As I have not access to Bessel's Observations, I do not know how far he may have anticipated me in these respects; but there will be no harm done even if my results should merely come in as corroborative of his."

Observatory, Madras.

Digitized by Google

Observations of the Satellites of Uranus. By W. Lassell, Esq.

		Ariel.	Umb.	Titania.			Oberon.		
1856.	G.M.T.	Position (Estimated).	Position (Estimated).	G.M.T.	Position.	Distance.	G.M.T.	Position.	Distance.
	h m	°	°	h m	° ′		h m	° ′	
Nov. 6	11 40	180	335	12 10	41 13		11 52	271 41	
						″			″
				12 39·5		28·69	12 28·5		37·83
28	10 5	249	215		212	(all estimations)		55	
29	11 15	160	80	11 27	175 36				
				12 48		32·70	12 17·8		42·37
30	10 15	328	50				11 7·0	351 34	
							10 33·0		43·40
Dec. 1	10 25	180		10 33·9	93 31		10 45·9	327 52	
				11 7·2		29·45	11 20·0		41·80
14	10 45	185	280	11 1·0	272 19		11 12·5	339 3	
				11 43·4		29·44	11 29·3		42·66
18	9 50	280	295	10 9·1	112 47		10 25·1	228 5	
				10 43·3		26·91	11 2·3		40·27
26	10 0	210		10 9·9	141 40		10 19·3	17 41	
				10 41·4		30·44	10 30·9		41·79
27	10 2	80	225	10 47·0	96 19		10 57·0	350 44	
				10 35·0		28·30	10 12·4		42·64
28				10 47·5	55 45		10 57·7	326 56	
1857.				10 26·2		29·08	10 3·1		41·35
Jan. 13							9 17·0	76 29	
							9 6·0		37·13

REMARKS.

Nov. 6. The sky gradually became hazy, and the measures of distance were taken with extreme difficulty.

Nov. 28. *Umbriel*, which is generally the faintest of the satellites, was not seen without patient attention for some time. The sky became cloudy before measures of any of the satellites could be procured.

Nov. 29. Vision very diffused and the planet moulding and ill-defined.

Nov. 30. There was a star in magnitude between the brightness of the faintest two satellites and *Titania*, and almost in the path of the latter, so that I was some time in ascertaining its nature. This is a very rare occurrence.

Dec. 14. Taking into account the bright moonlight, *Ariel* and *Umbriel* were remarkably well shown. I don't think the intrinsic brightness of *Ariel* is very inferior to that of *Titania*, but its proximity to the planet renders

Digitized by Google

it far more difficult to see. For this reason I have never been able to obtain in England satisfactory measures of distance of these inner satellites.

Dec. 18. Definition very bad and measures most difficult to take.

The instrument used was the 20-feet Equatorial with a magnifying power, generally, of 614.

Bradstones, near Liverpool, 4th April, 1857.

Erratum.—In the *Monthly Notices*, vol. xiii. p. 149, the position of *Oberon*, Nov. 2, instead of 206° 40′ should be 196° 40′. This error was discovered by Dr. Marth, who, in discussing these observations found this measure to stand out greatly from the series; and on reference to my MSS., I find it occurred in an erroneous addition in deducing the angle from the north point from the angle with the parallel.

Note to the Paper on Optical Phenomena in Occultations in the preceding Number. By Professor Powell.

"In my remarks on the observations, I put a suggestion whether the appearance observed by Prof. Challis might not have been a projection. I have since received a letter from that gentleman, in which he states, 'The depression which I noticed at the part of moon's limb when *Jupiter* reappeared was an actual inequality of the limb, and was as conspicuous before and after, as during the occultation.'

"He further observes that what he saw agrees well with Mr. Hartnup's description (*Monthly Notices*, vol. xvii. p. 73). He also saw the second satellite, at its reappearance, bisected by the moon's limb just at the extremity of the same depression.

"I am anxious to take the earliest opportunity of correcting any misapprehension on this point."

On the Correction of Sextant-Observations. By W. H. Simms, Esq.

In two papers recently laid before the Royal Astronomical Society I have discussed in detail the errors to which the several parts of the sextant are liable, and the effects of these errors upon observations made with that instrument. But as in the said papers the subject has been treated at some length, and as practical men, scientific explorers and navigators, who are in the habit of using the sextant, will be glad to have it placed before them in a simple and practical form, I omit on this occasion everything of the nature of investigation, confining myself to formulæ and examples, a careful consideration of which will enable any person tolerably well versed in the manipulation of tables to correct his observations, and thus to obtain results upon which he may rely to a much greater extent than he could upon such as he might obtain

Digitized by Google

from the simple readings corrected only for index-error in the ordinary way.

The principal error for which correction is required is that of eccentricity; an error from which few sextants are exempt, and which affects unequally the angles read from different points of the limb, the maximum effect being seldom less than thirty seconds, sometimes exceeding two minutes. The formula for correction reduced to its most simple form, and including the effect of index-error is

$$\Omega = \omega + \epsilon + \tfrac{1}{2} k \,.\, \sin\{v + \tfrac{1}{2}(\omega)\}^*$$

where ω is the reading made in the ordinary way; (ω) the degrees and minutes on the arc at the point of coincidence of divisions; ϵ, k, v, constants; and Ω the corrected angle. By means of this formula, the values of the constants being known, any reading may be corrected; or we may form a table of corrections for every 5 or 10 degrees of the arc, and thence take the particular correction required on each several occasion.

To find the values of the constants, three known angles must be observed, one near to each extremity, the third near the middle of the arc. Let the known values of these angles be, in order of magnitude, Ω_1, Ω_2, Ω_3; and let ω_1, ω_2, ω_3, be the uncorrected readings from the limb of the sextant; (ω_1), (ω_2), (ω_3), the degrees and minutes on the limb at the points of coincidence of divisions. Compute

$$c_1 = \Omega_2 - \Omega_1 - (\omega_2 - \omega_1) \qquad c_2 = \Omega_3 - \Omega_1 - (\omega_3 - \omega_1)$$

$$\theta_1 = \tfrac{1}{2}\{(\omega_2) - (\omega_1)\}; \qquad \theta_1' = \tfrac{1}{2}\{(\omega_2) + (\omega_1)\};$$

$$\theta_2 = \tfrac{1}{2}\{(\omega_3) - (\omega_1)\}; \qquad \theta_2' = \tfrac{1}{2}\{(\omega_3) + (\omega_1)\}.$$

$$\tan v = \frac{c_1 \,.\, \sin\theta_2 \,.\, \cos\theta_2' - c_2 \,.\, \sin\theta_1 \,.\, \cos\theta_1'}{c_1 \,.\, \sin\theta_2 \,.\, \sin\theta_2' - c_2 \,.\, \sin\theta_1 \,.\, \sin\theta_1'};$$

$$k = \frac{c_1}{\sin\theta_1 \,.\, \cos(v + \theta_1')};$$

$$\epsilon = \Omega_1 - \omega_1 - \tfrac{1}{2} \,.\, k \,.\, \sin\{v + \tfrac{1}{2}(\omega_1)\}$$

whence the constants are determined.

We may now for every 5° or 10° of (ω) compute and tabulate the values of $\frac{1}{2} k \,.\, \sin\{v + \frac{1}{2}(\omega)\}$; and the process of correcting any angle ω will then consist in the application, first of ϵ, then of the value of $\frac{1}{2} k \,.\, \sin\{v + \frac{1}{2}(\omega)\}$ standing opposite to (ω) in the table.

It is necessary only that the index-error should not change in the course of the observations from which we derive the values of the constants; but it may vary afterwards, and as a variation in this will produce one in the value of ϵ, we shall have to determine ϵ from time to time in the following manner:—

Let ω, ω' be the two readings which correspond to opposite contact of the sun's limb; (ω), (ω'), the degrees and minutes at

* v is the angle ZOY, and ϵ the quantity $\omega' - \frac{1}{2} \,.\, k \,.\, \sin$ ZOA′ of the investigation contained in the second of the papers laid before the Society.

Digitized by Google

coincidence of divisions. Then, $2r$ being the sun's apparent diameter,

$$2r = \omega + \epsilon + \text{quantity opposite } (\omega) \text{ in the Table}$$
$$-2r = \omega' + \epsilon + \text{quantity opposite } (\omega') \text{ in the Table}$$

and therefore $\epsilon = -\frac{1}{2}(\omega + \omega') - \frac{1}{2}$ sum of quantities opposite (ω) and (ω') in the table.

With respect to the three known angles to be observed for the determination of the constants; of these, the first may be either the sun's apparent diameter, or actual coincidence of the two images of a star, in which latter case the angle will be 0. The second and third should be distances of well-known stars from one another, these distances being computed for the occasion, or circum-meridian altitudes at a place of which the latitude is known. Each observation should of course be repeated several times.

To compute the apparent distance between two stars, we have the following formula:—

Let π_1, A_1 be the true polar distance and right ascension of the first star; π_2, A_2 of the second;

ζ_1, ζ_1' the apparent and true zenith distance of the first; ζ_2, ζ_2' of the second;

the polar distances and right ascensions being taken from the tables; and the zenith distances either computed, or derived from altitudes observed in the course of the observations of distance.

Compute

$$\log \tan \theta = \tfrac{1}{2}\{\log \sin \pi_1 + \log \sin \pi_2\} + \log \sin \tfrac{1}{2}(A_1 \sim A_2)\} - \log \sin \tfrac{1}{2}(\pi_1 \sim \pi_2);$$
$$\log \sin \tfrac{1}{2} D = \log \sin \tfrac{1}{2}(\pi_1 \sim \pi_2) - \log \cos \theta;$$
$$\beta = \tfrac{1}{2}(\zeta_1' + \zeta_2' + D)$$
$$\log \sin \psi = \tfrac{1}{2}\{\log \sin \beta + \log \sin (\beta - D) + \log \sin \zeta_1 + \log \sin \zeta_2 - (\log \sin \zeta_1' + \log \sin \zeta_2')\} - \log \sin \tfrac{1}{2}(\zeta_1 + \zeta_2)$$

Then, D′ being the apparent distance required,

$$\log \sin \tfrac{1}{2} D' = \log \sin \tfrac{1}{2}(\zeta_1 + \zeta_2) + \log \cos \psi.$$

The following is an example of the process:—

Suppose that on the 1st of March, 1857, in latitude 51° 30′ N., and the longitude of Greenwich, the observations were

1. Mean of ten readings for contact of sun's limb = + 30′ 11″; the sun's apparent altitude being 30°, and the Bar. $30^{in.}{\cdot}00$, Ther. 54°.

2. At $6\frac{1}{2}^h$ mean time. Mean of ten observed distances between *Capella* and *α Orionis* = 39° 27′ 5″.

3. At 7^h mean time. Mean of ten observed distances between *α Ursæ Majoris* and *Sirius* = 93° 17′ 23″.

The barometer and thermometer for observations 2 and 3 being $29^{in.}{\cdot}95$ and 40°.

On the 1st of March the sun's true diameter = 32′ 20″; and the difference of refraction for 32′ at altitude 30° is 1″. The

Digitized by Google

apparent vertical diameter therefore = 32′ 19″; and the first observation gives

$$\Omega_1 = 32' 19''; \quad \omega_1 = 30' 11''; \quad (\omega_1) = 0° 41'.*$$

Next to compute the apparent distance between *α Orionis* and *Capella* at $6\frac{1}{2}^h$ P.M.

	h m s		° ′ ″
A_1	= 5 47 26·64	π_1	= 82 37 21
A_2	= 5 6 8·53	π_2	= 44 8 52
$\frac{1}{2}(A_1 - A_2)$	= 20 39·06	$\frac{1}{2}(\pi_1 - \pi_2)$	= 19 14 15
or	= 5° 9′ 46″		

The altitudes were not observed. We must therefore compute the zenith-distances from the formulæ,

$$\log \tan \chi = \log \tan \phi + \log \cos H;$$
$$\log \cos \zeta' = \log \cos \phi - \log \cos \chi + \log \cos (\pi - \chi);$$

where ϕ is the colatitude of the place, and H the hour-angle of the star from the meridian.

Log tan ϕ	= 9·9006052	Log cos ϕ	= 9·8935444
Log cos H_1	= 9·9935398	Log cos χ	= 9·8960247
Log tan χ	= 9·8941450	Diff.	= 9·9975197
χ	= 38° 5′ 8″	Log cos $(\pi_1 - \chi)$	= 9·8529667
π_1	= 82 37 21	Log cos ζ_1'	= 9·8504864
$\pi_1 - \chi$	= 44 32 13	ζ_1'	= 44° 52 ′3″
		Refraction	= − 0 59
		ζ_1	= 44 51 4

Similarly we shall obtain $\zeta_2' = 5° 39' 19''$, $\zeta_2 = 5° 39' 13''$.

Log sin π_1	= 9·9963898	Log sin $\frac{1}{2}(\pi_1 - \pi_2)$	= 9·5178352
Log sin π_2	= 9·8429282	Log cos θ	= 9·9890911
Sum	= 9·8393180	Log sin $\frac{1}{2}$ D	= 9·5287441
Half	= 9·9196590	$\frac{1}{2}$ D	= 19° 44′ 49″
Log sin $\frac{1}{2}(A_1 - A_2)$	= 8·9541729		
Sum	= 8·8738319	D	= 39 29 38
Log sin $\frac{1}{2}(\pi_1 - \pi_2)$	= 9·5178352	∴ β	= 45 0 30
Log tan θ	= 9·3559967	β − D	= 5 30 52

* This may be either taken from the arc at the time of reading, or derived subsequently by adding to the degrees of ω the number of minutes taken from the vernier, and to the minutes of ω taken from the arc the number of seconds taken from the vernier.

Digitized by Google

Log sin β	$= 9{\cdot}8495482$	Log sin ζ_1'	$= 9{\cdot}8484783$
Log sin $(\beta - D)$	$= 8{\cdot}9827084$	Log sin ζ_2'	$= 8{\cdot}9936259$
Log sin ζ_1	$= 9{\cdot}8483535$	K	$= 8{\cdot}8421042$
Log sin ζ_2	$= 8{\cdot}9934983$		
Sum	$= 7{\cdot}6741084$	Log sin $\frac{1}{2}(\zeta_1 + \zeta_2)$	$= 9{\cdot}6300292$
K	$= 8{\cdot}8421042$	Log cos ψ	$= 9{\cdot}8985635$
Diff.	$= 8{\cdot}8320042$	Log sin $\frac{1}{2}$ D′	$= 9{\cdot}5285927$
Half	$= 9{\cdot}4160021$		
Log sin $\frac{1}{2}(\zeta_1 + \zeta_2)$	$= 9{\cdot}6300292$	$\frac{1}{2}$ D′	$= 19^\circ\ 44'\ 23''$
Log sin ψ	$= 9{\cdot}7859729$	D′	$= 39\ 28\ 46$

Hence the second observation gives

$$\Omega_2 = 39^\circ\ 28'\ 46''; \quad \omega_2 = 39^\circ\ 27'\ 5''; \quad (\omega_2) = 46^\circ\ 25'.$$

Similarly from the third we derive

$$\Omega_3 = 93^\circ\ 18'\ 43''; \quad \omega_3 = 93^\circ\ 17'\ 23''; \quad (\omega_3) = 100^\circ\ 33'.$$

Hence,

$$\Omega_2 - \Omega_1 = 38^\circ\ 56'\ 27''; \quad \omega_2 - \omega_1 = 38^\circ\ 56'\ 54''; \quad c_1 = -27'';$$
$$\Omega_3 - \Omega_1 = 92\ 46\ 24; \quad \omega_3 - \omega_1 = 92\ 47\ 12; \quad c_2 = -48;$$

$$(\omega_2) - (\omega_1) = 45^\circ\ 44'; \quad (\omega_2) + (\omega_1) = 47^\circ\ 6'; \quad \ell_1 = 11^\circ\ 26'; \quad \ell_1' = 11^\circ\ 47';$$
$$(\omega_3) - (\omega_1) = 99\ 52; \quad (\omega_3) + (\omega_1) = 101\ 14; \quad \ell_2 = 24\ 58; \quad \ell_2' = 25\ 19.$$

Log $-c_1$	$= 1{\cdot}43136$	Log $-c_1$	$= 1{\cdot}43136$
Log sin ℓ_2	$= 9{\cdot}62541$	Log sin ℓ_2	$= 9{\cdot}62541$
Log cos ℓ_2'	$= 9{\cdot}95615$	Log sin ℓ_2'	$= 9{\cdot}63106$
Sum	$= 1{\cdot}01292$	Sum	$= 0{\cdot}68783$
Nat. No.	$10{\cdot}302$	Nat. No.	$4{\cdot}873$

Log $-c_2$	$= 1{\cdot}68124$	Log $-c_2$	$= 1{\cdot}68124$
Log sin ℓ_1	$= 9{\cdot}29716$	Log sin ℓ_1	$= 9{\cdot}29716$
Log cos ℓ_1'	$= 9{\cdot}99075$	Log sin ℓ_1'	$= 9{\cdot}31008$
Sum	$= 0{\cdot}96915$	Sum	$= 0{\cdot}28848$
Nat. No.	$9{\cdot}314$	Nat. No.	$1{\cdot}943$

Whence,

$$\tan v = \frac{-10{\cdot}302 + 9{\cdot}314}{-4{\cdot}873 + 1{\cdot}943} = \frac{0{\cdot}988}{2{\cdot}930}. \quad \text{Log tan } v = 9{\cdot}52789;$$
$$v = 18^\circ\ 38': \quad v + \ell_1' = 30^\circ\ 25': \quad v + \tfrac{1}{2}(\omega_1) = 19^\circ\ 0'.$$

Digitized by Google

Log cos $(v + \ell_1')$	= 9·93569
Log sin ℓ_1	= 9·29716
Sum	= 9·23285
Log $- c_1$	= 1·43136
Log $- k$	= 2·19851
Log sin $\{v + \frac{1}{2}(\omega_1)\}$	= 9·51264
	1·71115 = Log 51″·4

Therefore $\epsilon = 2' 8'' + 25''{\cdot}7 = + 2' 33''{\cdot}7$; and the general equation is

$$\Omega = \omega + 2' 33''{\cdot}7 - 78''{\cdot}97 \cdot \sin \{18° 38' + \tfrac{1}{2}(\omega)\}.$$

We now compute the following table of the values of

$$\tfrac{1}{2} k \cdot \sin \{v + \tfrac{1}{2}(\omega)\}:$$

(ω)		(ω)		(ω)	
°	″	°	″	°	″
0	−25·2	35	−46·6	70	−63·6
5	28·5	40	49·3	75	65·6
10	31·7	45	51·9	80	67·4
15	34·8	50	54·5	85	69·2
20	37·8	55	56·9	90	70·8
25	40·8	60	59·3	95	72·2
30	43·7	65	61·5	100	73·5

and we are thus furnished with all we require for the correction of angles.

Suppose, for example, it were required to correct the angle 39° 27′ 5″ read from the limb of the sextant. Here,

$$\omega = 39° 27' 5'', \quad (\omega) = 39° 20' + 7° 5' = 46° 25'$$

and the corrected angle,

$$= 39° 27' 5'' + 2' 33''{\cdot}7 - 52''{\cdot}9 = 39° 28' 45''{\cdot}8.$$

A table similar to the above will continue to answer during a long period for the instrument for which it was obtained, the values of the constants k and v not being liable to disturbance except in consequence of serious accident or the operations of the maker in the course of repair. The constant ϵ is however liable to occasional disturbance, and its value must therefore be determined from time to time in the manner already explained. As an example we will suppose that on the 10th of March the following were the observations made for the purpose of a new determination of its value :—

Digitized by Google

Reading corresponding to positive contact of ⊙'s limb			$= \omega = +30'\ 16'',$	$\omega' = 0°\ 46$	
— — negative — —			$= \omega' = -34\ \ 8,$	$(\omega') = 5\ 12$	
Quantity opposite (ω) in the table	$= -25''.7$		$\omega + \omega' = -\ 3\ 52$		
— — (ω') —	$-28''.6$		Half $= -\ 1\ 56$		
	$-54''.3$	... ...	$-\ 27''.2$		
			$\epsilon = -\ 2\ 23''.2$		

and this new value of ϵ must now be applied to all angles alike, the second correction being taken from the table as before.

When the sun is observed for the purpose of determining the values of the constants, the image should be darkened by a shade placed before the eye-piece of the telescope.

The value of ϵ will in most cases be more or less affected by the interposition of shades before the index-glass, or behind the horizon-glass. The corrections due to each particular shade should therefore be determined, in order that in the event of our employing them for the purpose of darkening the image of the sun or moon in the course of ordinary observation, we may be prepared to apply the proper constant in the correction of the angle. This is done by observing, first, the contact of the images of the sun's limb with a shade before the eye-piece of the telescope only. The same contact being then observed with as many different combinations of the other shades as their number amounts to, we shall be furnished with as many simple equations, from which the several corrections may be determined.

A traveller on land treating the sextant in the manner above described ought very readily to obtain his latitude to the nearest second of arc: and if the results of his lunar distances be subsequently corrected for the errors in the tabular elements of the moon's place, his longitudes will probably be in most instances much within ten seconds of time from the truth. And as regards lunar observations at sea, the results must of course be materially affected by the correction of the observed angles to an extent exceeding in general the amount of probable error arising, even under unfavourable circumstances, from the difficulties attending the operation, and from deficiency of power in the instrument.

On the Value of the Constant of Refraction, as determined from Zenith-Distance Observations of Stars near the North and South Horizon, made at the Royal Observatory, Greenwich, in the years from 1836 *to* 1854. By the Rev. Robert Main, M.A.

The object of this paper is stated by the author to be the determination of the degree of accuracy with which Bessel's Refraction Tables, given in the *Tabulæ Regiomontanæ*, represent the star-observations made at Greenwich. Those tables, as is well known,

Digitized by Google

are mainly derived from the *Fundamenta*, the only change of importance being the increase of the mean refractions as far as 85° zenith distance in the proportion of 1 : 1·003282, and in the substitution of values for the mean refractions of stars below that limit, empirically derived from observation.

This break of continuity in the tables rendered it necessary to reduce all the errors ultimately to errors of the tables given in the *Fundamenta*, and to deduce the correction which it would be necessary to apply to the mean refractions given in that work.

The author enters into a discussion of the method which it would be necessary to adopt in the investigation, if the errors were ultimately found to be of sufficient magnitude to affect sensibly the places of the stars by which the latitude of the Observatory has been determined, which is fortunately proved not to be the case in the use of the refractions of the *Tabulæ*.

With regard to the materials for the investigation, it was first necessary to extract from the Greenwich Twelve Year-Catalogue, and the subsequent Star Catalogues, all the southern stars whose meridian-zenith distances at Greenwich are greater than 70°, and all the circumpolars of greater than 70° zenith-distance at their transit beneath the pole.

In the treatment of the north stars, the mean north polar distances derived from the individual observations are compared with those given in the Greenwich Catalogues reduced to the proper epoch by the annual variations given in the British Association Catalogue, the stars passing the meridian so near the zenith at the upper transit as to make the deduced places given in the Greenwich Catalogue independent of moderate errors in the refraction-tables.

With regard to the southern stars, only such were available as could be compared by means of observations made at some southern observatory near whose zenith they pass the meridian. One list of stars affording such comparison is that given in a paper by the late Professor Henderson, and printed in Vol. X. of the *Memoirs* of this Society. Only fourteen stars, however, were furnished by this catalogue which could be compared with the Greenwich Observations. Other stars for comparison were furnished from Mr. Maclear's observations of zenith-distance made with Bradley's sector at the Cape Observatory, in connexion with the triangulation. These zenith-distances, when reduced to mean north polar distances by the application of Henderson's colatitude, furnished thirty-three additional stars available for the investigation.

The author then points out the circumstances in Bessel's refraction-theory, which rendered it necessary to arrange in order of temperature the individual errors of refraction for all such stars as were observed with sufficient frequency and under different atmospheric circumstances, to discover whether any law of error were observable dependent upon temperature. The arrangement shows pretty clearly that there is no sensible error due to this element.

Digitized by Google

The remaining tables in the memoir are designed to show the errors of mean refraction of the *Tabulæ*, and the arrangement is therefore according to the order of the zenith-distances of the stars. All the errors of mean refraction of the *Tabulæ* are reduced to errors of the *Fundamenta* by comparison of the errors of the two sets of tables, and the errors of the *Fundamenta* are then grouped for convenient intervals of zenith-distance, and the results derived from the three lists of stars are finally combined.

The conclusions derived from the whole investigation, with regard to errors of mean refraction, are the following :—

1. As far as 82° zenith-distance the mean refractions of the *Tabulæ* are very nearly correct, and no corrections could be safely applied.

2. From 82° to 85° zenith-distance the logarithms of the refractions of the *Tabulæ* require diminishing by 0·00100.

3. From 85° to the horizon it seems expedient to give up the use of the mean refractions in Bessel's Supplementary Tables given in the *Tabulæ*, and to use those of the *Fundamenta*, diminishing the logarithm by 0·00066.

A projection of the star *Spica Virginis* on the moon's disk was witnessed on the 12th of March by C. R. Chalmers, Esq., at Barrie, Simcoe County, Canada West. His note of the occurrence runs thus: "The sky was cloudless, and I watched the star up to the bright edge. I then expected to lose sight of it, but it continued to advance on the face of the moon until I could distinctly see the limb *outside* the star. *Of this I am quite positive.* I counted several seconds from the first contact till the disappearance of the star, which was instantaneous. The star had a curious planetary appearance, which was also remarked by a friend at Toronto with a 4¼-inch refractor. The telescope I used is a 42-inch, by G. Dollond, of 2¾ inches aperture. Power 60." Mr. Chalmers adds that the superiority of the climate of Canada over that of England is very marked, a 3-inch aperture in Canada doing the work of a 4-inch in England.

Experiences with a Free-Revolver Stand for a Telescope at Sea, during a Voyage to Teneriffe in the Summer of 1856. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.

(*Continued from the December Number.*)

"The opportunity of making these experiments was afforded by the voyage that formed part of the astronomical expedition to Teneriffe last summer, and the vessel in which they were made

Digitized by Google

was the yacht Titania, placed at my disposal for this purpose by the princely liberality of Robert Stephenson, Esq. M.P.

"The first point to get clear ideas upon was the amount as well as the character of the angular disturbances that the vessel underwent; to which end continual appeal was made to the Naval Clinometer, previously described. (See page 38.) The disturbances were at once found to be larger in angular amount, and quicker as to time, than had been expected. The results, therefore, of the new instrument were frequently checked by direct measurement on deck by vision and ordinary angular instruments, and were invariably so well confirmed in all their most characteristic features, that full confidence was felt in the clinometer; and it was found especially useful at those times, as at night, when the direct method was not available.

"A table of observations from June 26th to July 7th is subjoined, and represents the voyage from the Channel to the African coast; and from it we gather that the rolls of the yacht varied in number between 16 and 33 per minute, and in mean angular value from 3° to 20°; the pitches of the vessel being at the same time almost equal in number, but only of about one-fifth the angular amount of the rolls.

"Examining the table further, we find that in a calm outside the Channel the rolls were 21 per minute, of 3° each; that on a gale growing up, and having its swell unmixed by others, the number of rolls was lowered to 17 per minute, but their angular extent increased to 20°, returning again to its former characteristics, when after several days the wind died away to the west of the Portuguese coast. In the broken squally weather before making the trades, and in a confessedly cross sea, where two or more swells met, the number of rolls rose as high as 33 per minute with an average extent of 8°; while when the N.E. trade was once fairly entered, and its own long regular swell ruled supreme along the surface of the water, the number went down to 19 per minute, with an angular extent of about 10°. Day after day as we sailed in the trades, the wind, while it kept one invariable direction, constantly increased in velocity; and so did the rolls, preserving nearly the same number per minute, continually increase in angular magnitude until they had reached to above 20°. How much more they would have grown to it might have been interesting to have ascertained, but we had then, on July the 8th, arrived at the end of our voyage—the island of Teneriffe, situated in the midst of the brunt of the trade wind.

"Something more, however, deserves to be considered with regard to the rolls, viz., the angular magnitude of each roll, as distinguished from the quantities already given, which are the average of a large number.

"Thus, on July 6th, the following are the angular values, in degrees, of as many rolls observed during two minutes:—12, 10, 8, 6, 4, 10, 20, 16, 17, 21, 20, 19, 22, 14, 11, 18, 19, 13, 17, 10, 14, 13, 24, 31, 29, 23, 13, 21, 10, 17, 12, 12, 14.

Digitized by Google

TABLE.

Date.	Latitude N.	Longitude W.	Wind. Velocity in Miles per hour.	Wind. Direction.	Character of Sea.	Rolls of Yacht. Number per Minute.	Rolls of Yacht. Angular Extent.	Angular Rolling in one Minute	Pitches of Yacht. Number per Minute.	Pitches of Yacht. Angular Extent.	Rolls of Gimbal-table in Main Cabin. Number per Minute.	Rolls of Gimbal-table in Main Cabin. Angular Extent.	Rolling of Gimbal-table in one Minute
1856.	°	°					°	°		°		°	
June 26	50	4	0	0	Calm.	21	3	63	21	1	..	..	..
27	49	4	3	E.	Swell growing.	17	7	119	16	1	..	..	..
28	48	6	13	E.	Waves high.	17	12	204	16	1	45	8	360
29	46	9	15	N.E.	Waves running high.	17	20	340	19	2	43	7	301
July 1	43	11	2	S.	Broken sea.	20	9	180	21	3	40	..	280
2	42	11	2	N.	Glassy swell.	*(19	6	114	20	2)	..	..	..
..	..	..	..	..	..	20	4	80	20	2	..	..	..
3	41	11	5	N.W.	Smooth water.	18	4	72	..	..	..	..	..
At 4 P.M.	..	..	8	N.W.	Wind rising and cross sea.	33	8	264	22	3	..	..	..
At 6 P.M.	..	..	8	N.W.	Two swells interfering.	25	10	250	27	4	46	4	184
4	39	11	5	N.W.	..	21	6	126	22	2	..	..	..
5	37	12	8	N.N.E.	Rolls regular.	18	6	108	18	2	28	4	112
3 h.	..	..	10	N.N.E.	..	19	10	190	..	..	..	..	..
6 h.	..	..	12	N.N.E.	..	17	15	255	..	..	..	..	..
6	34	13	13	N.N.E.	..	19	16	304	18	1	27	8	216
7	31	15	15	N.E.	..	16	20	320	16	4	..	..	..

* These observations were by direct measurement on deck.

Digitized by Google

"And, again, on July the 7th, the following series was obtained in 8 consecutive minutes:—

°	°	°	°	°	°	°	°
22	22	20	9	25	13	20	28
21	17	17	9	21	16	22	31
11	17	16	10	16	18	24	27
8	19	25	7	11	17	21	21
17	11	26	9	13	21	13	22
23	18	20	13	19	20	21	19
16	20	17	15	21	19	26	10
23	10	14	13	23	16	21	9
16	13	9	9	29	12	17	19
21	15	5	10	29	11	15	27
18	17	4	16	26	12	13	29
18	15	8	18	24	11	12	22
22	11	14	16	18	10	13	13
22	12	14	13	...	...	12	11
26	15	...	12	16	16	13	15
27	...	...	15	16	17	...	...
18	...	...	23	15	...	20	18

"These numbers, while vividly demonstrating the amount of disturbance of the yacht's deck, also indicate the very compound nature of the rolling of a vessel at sea; for, through the individual undulations, there run evidently others of a longer period, and through those others still longer. Indeed, I was never able to get any regularly recurring series of numbers; and after the passage of any given maxima and minima, there were sure to appear in the course of time others of yet higher order and greater intensity. On one occasion, after long watching, I caught a roll of 40°; and this did, while rolls of 31° did not, set things generally rolling and tumbling about in the cabin. As this species of actual and social disturbance below deck only occurred three or four times in the day, we may assume that there are amongst the waves of the sea undulations having a period of several hours, and with their crests from 30 to 40 miles apart.

"Such a result shows that no practical increase in the size of ships will altogether do away with their rolling at sea—that rolling which tends so to the discomfiture of the passengers, and the impossibility of taking telescopic observations. Neither can the old-fashioned plan of swinging tables avail anything. This was shown from principle in the paper of last year, and was found in practice on this voyage; for, as may be seen in the tabular representation of the observations, measures were made of the rolling of the dinner-tables on board the yacht; the tables being hung on pivots with a heavy weight below. They answered their purpose famously as dinner-tables for rough sea weather, for the plates and dishes kept their places marvellously. But when tested by

Digitized by Google

the clinometer, or by the sun, they were found to be continually oscillating, through a less angle certainly than the yacht was rolling to, but so much more quickly, that the angular amount, multiplied by the number of vibrations, generally gave a larger total quantity of displacement in a minute for the swinging-table than for the yacht. In the little yacht the motions were doubtless much more excessive than in the larger class of ships now employed in long voyages; but if so, the occasion was all the more proper for testing the 'Free Revolver Stand,' as a means of eliminating from an astronomical instrument both the rolls and the pitches of a vessel.

"One of these instruments, on the principle already described, was on board, and was set in action on the 3d of July.

"The telescope mounted was a small one, magnifying 7 times; and having an eye-hole of one-eighth of an inch. The revolver was 1 foot in diameter, weighed 10 lbs., and was driven by two sets of wheel-work acting on either side of the spindle. The apparatus was arranged inside a sort of observatory box, into which the observer could insert his head and two hands, while openings for observations could also be made. The only convenient place on the deck for erecting the instrument was near the stern, where was the maximum of the up and down movement, and the look-out was over the quarter, with the full effect of the rolling; all this, however, was well for testing the new principle.

"The sailors were called up to work the driving-wheels, and when they had got up about 80 revolutions per second in the revolver, the wheels were withdrawn, the gimbal rings unclamped, and I had the satisfaction, for the first time that any one had had, of looking at sea through a telescope steadied by the same mechanical effort as that which preserves the constancy of the earth's axis in space.

"The following practical points were soon ascertained: first, that in spite of the egregious rolling of the yacht, which must be partaken of by the observer, but is happily not partaken of by a telescope mounted as ours, there is no difficulty in keeping the eye *en rapport* with the eye-piece, although in the present case the size of the eye-hole is extremely small; second, that the position of the platform of the telescope can be adjusted with great nicety in any direction as respects deviation from the horizontal plane, by simply pressing on one of the gimbal rings, in a direction 90° removed from that in which it is desired that motion should take place; and, third, that the telescope can be adjusted in azimuth or altitude by rack and pinion, without sensible derangement to the position of the platform.

"Having performed these adjustments, and brought the horizon of the sea into the field of view, I was delighted to find it remain there, absolutely uninfluenced by the rolling and pitching of the yacht; nay, it even remained bisected on the wire sufficiently long for the captain, the first and second mates, and several of the sailors, to look in and bear witness of the fact. They saw

Digitized by Google

this consummation long desired at sea, and they took kindly to the instrument, though it was an innovation on nautical practice.

"In order to perfect the balance of some parts of the machine, which had left its maker's shop rather unfinished, I kept the sailors for several days working the driving-wheels while I was experimenting; they laboured at them with enthusiasm, indeed, rather too much so, for one unfortunate evening, when the instrument was so nearly perfect that I hoped in the course of the night to essay the grand nautical problem of observing an eclipse of one of *Jupiter's* satellites, the sailors, impatient of the difficulty of getting up immediately the full speed, clapped on a rope to the handle of the driving-wheel, and pulled away in such style, that they twisted the strong steel driving-axle in two, and were themselves laid flat along the deck.

"The practical sufficiency, however, of the single-wheel revolver stand, for correcting the rolling and pitching of a ship at sea, had been abundantly proved. And more than this, the azimuthal deviations of the yacht, which had been previously neglected as comparatively trifling, so long as rolling and pitching existed, were now found, when these were eliminated, and yawings left as the sole residual, to be absolutely so large, and so annoying to telescopic vision, as imperatively to demand attention and correction by the same revolver method also. On looking into the telescope, for instance, on the above-described stand, no change of plane from the horizon of the sea could be discovered; but any point in that plane, as a distant ship, was oscillating backwards and forwards in the horizontal direction twenty times in a minute; this being the effect of the azimuthal changes of the position of the yacht not having been eliminated as had been the rolling and the pitching.

"The application of a second revolver to the apparatus which was employed on board, to enable it to eliminate all the angular disturbances of the yacht would be easy, as indeed I described in my paper of last year, and such an addition should be a necessary preliminary to any further trials at sea."

Dr. William Stroud, in two letters to Dr. Lee, draws attention to two lunar eclipses which he imagines to be important as helping "to dispel some doubts and difficulties which still beset the chronology of the Christian era." The first of these he supposes to have happened at the autumnal equinox of the year B.C. 5, and the latter in the year A.D. 30, at the Paschal full moon corresponding to the time of the Crucifixion of our Saviour.

With regard to the first of these, it appears that there were two lunar eclipses in each of the years B.C. 4 and B.C. 5, one at the vernal and the other at the autumnal equinox; and they are

Digitized by Google

therefore of little use in fixing, in connexion with the well-known passage of Josephus, the date of Herod's last illness.

With regard to the eclipse of A.D. 30, its connexion with the date of the Crucifixion appears to rest only on the figurative expressions quoted by St. Peter from the prophet Joel: "The sun shall be turned into darkness and the moon into blood before . . ." As the purely astronomical portion of such speculations may rightly be considered to fall within the province of this Society, perhaps some Fellow possessing the leisure and requisite means, will oblige Dr. Stroud by undertaking an accurate computation of the eclipses in the above-mentioned years, with the data of the best modern tables.

Abstract of a Memoir in Vol. IX., Part IV. of the Cambridge Philosophical Society's Transactions, entitled, 'On the External Temperature of the Earth, and the other Planets of the Solar System.' By W. Hopkins, Esq. F.R.S. and V.P. C.P.S.

The author of this paper states in the outset that he was led into the researches therein contained in consequence of the interest excited by recent speculations involving the conditions of existence of organised beings,—conditions comprising heat, light, moisture, &c., of which he proposes to examine the one of temperature. He remarks that we have not the means of determining the actual superficial temperature of any planet besides our own, but that we know it must mainly depend (1) on the temperature of planetary space, (2) on the direct heat which the nearer planets receive from the Sun, and (3) from the modifications which result from their atmospheres, the positions of their axes of rotation, and the conductivity and specific heat of the substances forming their outer crusts,—modifications which may have a far greater influence than has been generally supposed.

He commences by general remarks and illustrations on the various modes by which heat may be transmitted, by complete or partial radiation, by conduction, or by convection, applying them, in the first place, to the Earth, and considering separately the mean temperature and the annual and diurnal variations.

"It is almost entirely by direct radiation that the solar heat reaches the Earth's surface, when the atmosphere is pure. . . . In the transference of the heat back again, all the other modes of transmission must be more or less effective, though we are altogether ignorant of their relative degrees of efficiency. It is, however, sufficient for us to know that none of them can be effective unless the temperature of the atmosphere decrease continually as we ascend from its lower to its upper regions. . . . . It will be my object to examine the data we possess for determining numerically what would be the effect of an *increase* or *diminution* of our atmosphere on terrestrial temperature, and also what is the actual effect

Digitized by Google

of the Sun's heat on that temperature. We shall then be able to judge what may be the probable influence of similar causes on the temperatures of the other planets."

The author avails himself extensively of the previous researches of Poisson, presenting the results, however, in a simpler form. He first confirms, by several independent routes of inquiry, Poisson's resulting value of the temperature of the constituent particles of the atmosphere at its upper limit,

$$-273^\circ \text{ Centigrade},$$

remarking that this very low temperature is not to be confounded with that of surrounding space, but is to be understood to be that of the air at a point where its elasticity is lost, and it is reduced to the state of a fluid.

As his data for obtaining the decrement of temperature for a unit of height, he discusses the observations of Mr. Welsh in his four balloon ascents from Kew, in which were found severally,—

1852.	Height reached.	Decrement per 1000 Feet.
Aug. 17	19510 feet	3°·434 (F.)
,, 26	19100 ,,	3·440
Oct. 21	12640 ,,	3·431
Nov. 10	22930 ,,	3·205

Mr. Hopkins passes over the third of these results as obtained by a considerably less ascent, and attributes the discrepancy of the fourth to a difference of 19° (F.) in the temperature of the air at sea-level on Nov. 10. He remarks that such observations would alone enable us to form some estimate of the effect of an assigned increase or decrease in the atmosphere; an increase or decrease by a quantity corresponding to a space of 1000 feet at the surface, for example, sufficing to raise or lower the superficial temperature by 3° (F.), and proportionately for greater values.

As this is the most striking point in the memoir before us, we pass over the author's conclusions respecting distribution of temperature and periodic variations, to give his summary of results obtained with reference to the Earth, calling especial attention to his paragraph (3).

"(1) I have endeavoured to explain, as fully as possible, the manner in which the atmosphere produces its influence on the temperature of the Earth's surface; and to show that the temperature of the constituent particles of the atmosphere at its upper limit must be exceedingly low.

"(2) If as much atmosphere were removed from the Earth as now forms an inferior stratum of about 525 feet in thickness, the mean annual temperature of each point on the Earth's surface would be diminished by 1° (C) . . . . . If the thickness of the stratum removed were greater, the diminution of temperature would be greater in the same ratio . . . . An increase would produce an exactly similar, but opposite effect.

Digitized by Google

"(3) After explaining Poisson's method of treating the problem of terrestrial temperature, and his mode of estimating the direct effect of the solar heat radiating to the Earth. . . . I have shown that the *whole effect* of the solar heat on the mean value of this superficial temperature is equal to nearly twice the immediate effect, which was the object of Poisson's calculation, except in cases in which there may be a considerable horizontal transference of heat from local causes.

"(4) Assuming that the temperature of every part of the Earth's surface would be the same in the entire absence of the Sun's influence, I have estimated that temperature at $-39°{\cdot}5$ (C). This must not be confounded with the temperature of that portion of stellar space in which the solar system now exists, a temperature which we have not the means of determining.

"(5) I have also shown that *annual inequalities* in the temperature of the lower stratum of the atmosphere are nearly equal in amount to those in the Earth itself at its surface, with exceptions similar to those mentioned in (3)."

The author next shows how that, if the Earth were placed at the distance of *Jupiter*, where the intensity of solar radiation is diminished in the ratio of 1 to 27 nearly, the mean annual temperature at the Equator would be $-36°{\cdot}9$ (C) and at the Pole little more than $-39°{\cdot}5$ (C), leaving out of consideration the effect which this reduction of temperature would have on the height, density, and transmissive quality of the atmosphere. The annual inequality at any latitude μ would be about

$$\pm 0°{\cdot}6 \sin \mu \quad \text{(C)}.$$

or sensibly negligible; and in passing from the Equator to the Poles the whole change of temperature would never exceed about 3° (C). The addition of 35,000 or 40,000 feet to the thickness of the Earth's atmosphere, if revolving in *Jupiter's* orbit, would unquestionably elevate her equatorial temperature to about that of our temperate zone at present. The principal difference between the Earth and *Jupiter* at this distance would arise from the greater density of the atmosphere about *Jupiter*, consequent on the greater mass; but the observations of Mr. Welsh, continued to a point at which the density of the atmosphere observed was reduced to less than one-half, lead to the conclusion that the transmissive power is nearly independent of the density, and that there would be no material difference in the rate at which the temperature would decrease in receding from the surface. "There seems reason to believe that *Jupiter* has an atmosphere much greater than that of the Earth, and it may be of such a thickness as entirely to counterbalance the defect of heat derived from the Sun by direct radiation. His climate must, however, differ from that of the planets nearer to the Sun, in the comparative absence of periodical variations. . . .

"The cases of the planets more remote than *Jupiter* are still more simple than that of *Jupiter* himself, since solar radiation can have no sensible effect whatever upon them. If the Earth were

Digitized by Google

placed in the position of any one of these planets, and equilibrium of temperatures due to internal and external causes respectively were so far established as it is under existing conditions, her superficial temperature would, according to our previous calculations, be about $-39°{\cdot}5$ (C); but if her atmosphere were increased to the requisite amount, this temperature might be increased, as we have seen, in any proposed degree, and so it must be with these remote planets themselves. Their superficial temperatures must be entirely uniform independently of variations due to local or temporary causes, and must depend on the quantity of atmosphere by which they may be respectively surrounded."

Treating next of the planet *Mars*, whose circumstances do not greater differ from those of the Earth, Mr. Hopkins calculates that the mean temperature of the Earth with her present atmosphere, moving in the orbit of *Mars*, would be, at the Equator $-10°{\cdot}7$ (C), and at the Pole $-34°{\cdot}3$ (C); an additional depth of atmosphere to the extent of 15,000 or 20,000 feet would however suffice to raise the Equatorial temperature to about $15°{\cdot}5$ (C) or 60° (F).

For the Earth, moving in the orbit of *Venus*, with her present atmosphere and inclination of axis, the author similarly finds as the mean temperature of the Equator 95° (C), and of the Pole $16°{\cdot}5$ (C), both of which would doubtless be much modified by lateral transference. The maximum annual inequality at the poles is estimated at about $\pm$ 32° (C), but the inclination of axis usually adopted as existing for *Venus* herself would cause her seasons to be totally different from those of the Earth. Passing over the conclusions on this part of the subject, it is inferred, that a deduction of a superficial stratum of 25,000 feet of atmosphere would reduce the temperature of the equinoxial regions of *Venus* to that of the temperate regions of the Earth, that of her polar regions exceeding our tropical temperature by 12° or 13° (C). The direct heat of sunshine during the day would be about double that of our own. Certain further and allowable assumptions might materially modify these results, and permit the conclusion that large portions of the surface of *Venus* might be habitable by beings little better calculated than the human race to bear the extremities of heat and cold.

The author treats also of the case of our Moon, assuming her to be devoid of atmosphere, and with this application of his formulæ closes the subject.

Extract from a Letter received by the Astronomer Royal from Mr. Otto Struve, dated April 7.

"Has it been remarked by English astronomers that, this spring, the breadth of the obscure ring of *Saturn* was, on the following ansa, double (or at least one and six-tenths) of that on the preceding ansa? This feature was so striking on March 20, that it could be seen even by unpractised observers on the first glance."

Digitized by Google

Lord Wrottesley has favoured the Society with a communication of some observations of the appearance of the planet *Saturn*, made by his assistant, Mr. Frederic Morton, in the months of January and February last. Powers ranging from 320 to 600 were applied to the 11-feet Equatorial of $7\frac{3}{4}$-inches aperture.

On Jan. 20, the fine mark on the outer ring (A) was seen defined with great sharpness, and again by glimpses on the 29th.

The dusky ring (C) was generally observed to be bounded by a sharply-defined inner edge, with a black sky between it and the ball of the planet. On these occasions the common boundary between (C) and the middle ring (B) was never well marked, a phenomenon which Mr. Morton attributes to the apparent overlapping of the outer edge of the dusky ring on the inner edge of the middle ring. The shading of the inner portion of the ring (B) was seen to extend from the ring (C) to the middle of (B). Other observers have, however, noticed a more luminous streak between the shading on (B) and the outer edge of the dusky ring.

Lieut. Tennant has forwarded a printed slip containing further data relating to the annular eclipse of the Sun on the 18th of September next. As his table of limiting lines has been already given in page 18, and local phases must be principally serviceable to residents in India, it appears sufficient to state that this additional information may be obtained by reference to the *Roorkee Almanac* for the N.W. Provinces.

In consequence of the miscarriage of a letter, the death of our respected associate, Prof. Colla, late Director of the Observatory at Parma, has not hitherto been announced. Professor Pigorini, in a letter to Mr. Hind, informs the Society that he has been intrusted provisionally with the direction, until the Government makes some permanent arrangement.

A reprint has been made (in 8vo.) of Professor Hansen's Supplement to his Solar Tables, a paper which appeared in the last number. Prof. Hansen informs the Astronomer Royal that it is his intention to send the two Supplementary Tables, with the necessary explanation, to Copenhagen, to be printed in 4to. to correspond with the volume. It may, however, be convenient to some of our members to obtain copies of the communication to the *Monthly Notices*, for temporary use. They may be had by possessors of the Solar Tables on application to the Assistant Secretary at the apartments of the Society.

Digitized by Google

Considerable difficulty is anticipated in the re-discovery of the planet *Daphne*, detected on the 22d of May last year by M. Hermann Goldschmidt, when already far past opposition. The planet was estimated at the first little to exceed the 12th magnitude, and before the 20th of June it was found impossible to procure another observation even with the Berlin refractor.

It has been thought desirable to portion out the region of the heavens in which it may be expected to appear during the ensuing opposition, and a notice to that effect has just been put forth in the *Astron. Nach.*, with the intimation that Dr. Luther will especially undertake to search during August, September, and October, between 0^h and 1^h R.A.; Dr. Bruhns, between $23^h\ 0^m$ and $23^h\ 30^m$; M. Chacornac, between $23^h\ 30^m$ and $24^h\ 0^m$; and M. Goldschmidt, between 22^h and 23^h, as well as between $23^h\ 30^m$ and $24^h\ 0^m$. M. Pape of Altona will search between $22^h\ 30^m$ and $23^h\ 0^m$; and will shortly prepare an Ephemeris to guide observers in the adoption of limits within which to confine their attention. The co-operation of other observers in the examination, particularly, of hours 22 and 23, is solicited by Dr. Peters. The following Elements have been computed by Professor Valz of Marseilles:—

Daphne.

Epoch 1856. May 31·429.*

	°	′	″
M =	330	19	54
π =	231	5	48
Ω =	179	29	10
i =	15	0	9
φ =	12	26	12
a =	2·4899		
μ =	903″·10		

* Probably mean Marseilles time.

An account of his lecture on the 8th of April, on the Parallax of the Sun, which the Astronomer Royal has kindly promised to send, is unavoidably postponed to another Number, from the pressure of other astronomical business, and the necessity of waiting the preparation of a copper-plate containing the diagrams in illustration.

ERRATA.

Vol. XIII. page 149, Position of *Oberon* on Nov. 2, *for* 206° 40′, *read* 196° 40′.

Vol. XVI. page 221, line 9 from the bottom, *for* immersion, *read* emersion.

Digitized by Google

CONTENTS.

	Page
Publication of Vol. XXV. of the *Memoirs*	165
Recommendations by the Editor	ib.
Greenwich Observations of Small Planets	167
The Astronomer Royal. On a Variable Star	169
Discovery of a new Planet, and Observations	ib.
Observations of D'Arrest's Comet (I. 1857)	170
Passage of D'Arrest's Comet over a fixed Star	171
Observations of Bruhns's Comet (II. 1857)	ib.
Elements of Ephemeris of Bruhns's Comet	173
Letters of Capt. Jacob to Mr. Grant	ib.
Mr. Lassell. Observations of the Satellites of *Uranus*	175
Professor Powell. Note on a previous Paper	176
Mr. W. H. Simms. On the Correction of Sextant-Observations	ib.
Rev. R. Main. On the Value of the Constant of Refraction	182
Mr. C. R. Chalmers. Projection of *Spica* on the Moon	184
Experiences with a Free-Revolver Stand, by Professor Smyth	ib.
An Application by Dr. Stroud, made through Dr. Lee	189
Abstract of a Memoir, by W. Hopkins, Esq.	190
Miscellaneous	194

London :—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, May 7, 1857.

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *May* 8, 1857. No. 7.

G. B. AIRY, Esq., Astronomer Royal, in the Chair.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Months of April and May, 1857.

(*Communicated by the Astronomer Royal.*)

Hebe..

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	° ′ ″
1857, Apr. 11	8 2 17·6	9 22 12·21	68 42 46·96

Iris.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Apr. 6	12 43 1·6	13 43 59·53	107 54 49·53
8	12 33 20·7	13 42 10·17	.....
11	12 18 46·7	13 39 23·45	107 27 21·41
14	12 4 10·7	13 36 34·67	107 9 33·04
15	11 59 18·8	13 35 38·53	107 3 30·56
17	11 49 34·9	13 33 46·18	106 51 3·47
18	11 44 43·3	13 32 50·27	106 44 39·16
20	11 35 0·5	13 30 59·00	106 31 50·72

Digitized by Google

Psyche.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Apr. 11	8 30 4·9	9 50 4·05	76 12 22·58

Proserpine.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Apr. 11	9 48 21·2	11 8 33·23	80 5 9·87
17	9 22 25·7	11 6 12·83	80 4 12·17

Euphrosyne.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Apr. 18	12 59 51·5	14 48 10·88	113 26 41·14
23	12 35 23·1	14 43 21·16	113 34 56·05

There is much doubt whether any of the above places are those of *Euphrosyne*.

Polyhymnia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, Apr. 7	10 19 17·2	11 23 48·07	85 30 7·94
11	10 1 30·9	11 21 45·05	85 17 10·58
18	9 30 10·4	11 17 55·31	84 57 44·23

There is some doubt whether the observations of April 11 and 18 are those of *Polyhymnia*.

Ariadne.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, May 4	10 22 7·5	13 13 5·86	103 26 20·61
5	10 17 28·0	13 12 22·16	103 19 15·61
7	10 8 14·1	13 10 59·79	103 5 18·60
8	10 3 39·5	13 10 21·01	102 58 31·52

The observations of *Ariadne* have been corrected for Parallax by means of Mr. Pape's Ephemeris (*Ast. Nach.* 1081).

Digitized by Google

Fides.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Apr. 15 8 47 57·8	10 23 46·10	78 35 10·95
18 8 36 3·4	10 23 39·43	78 38 57·81

Extract of a Letter from M. J. Johnson, Esq. to the Astronomer Royal, dated May 7, 1857.

"I see in the last *Monthly Notice* a note from you calling attention to the variability of 3345 B.A.C. This star is No. 25 of Mr. Pogson's Catalogue of Variables where it is called after Argelander R *Leonis.* Its variability was discovered by Koch in 1782. Mr. Pogson has a long series of observations of it, and tells me his attention has been particularly drawn to it in consequence of the great irregularity of its changes and decided variability of colour. The star is now approaching the period of maximum brightness."

Note on the Variable Star 420 (*Mayer*) *Leonis, or R Leonis of Argelander.* By J. R. Hind, Esq.

"There appears to be a little confusion about the history of the star to which the Astronomer Royal has directed attention at p. 169 of the *Monthly Notice* for April, B.A.C. 3345, or, to call it by its more usual designations, 420 (*Mayer*) *Leonis,* or R *Leonis* of Argelander.

"The variability of this star has been known since 1782, and was detected by Dr. J. A. Koch of Dantzic, as may be seen from the *Berliner Jahrbuch* for 1788. By a typographical error or inadvertence the period is stated in Sir John Herschel's *Outlines of Astronomy* to be 'many years;' but, notwithstanding its fluctuations are subject to occasional irregularities, it would appear from the latest data published by Professor Argelander that the period given by the discoverer at p. 96 of the *Berliner Jahrbuch* for 1818, viz. 312 days, is nearly correct. The star has been said to vary from $5\frac{1}{2}$ magnitude to invisibility. I have had it under constant observation for some years past, as it falls within our ecliptical chart for Hour X., but have never found it below the $10\frac{1}{2}$ magnitude; and I am inclined to think Mr. Pogson is correct when he assigns as its *ordinary* limits of variation 5–10 magnitude. (See *Radcliffe Observations,* vol. xv.) The maximum for the present year is fixed on June 21 by Professor Argelander, in the

Digitized by Google

letter of which an extract was published in the *Monthly Notice* for March last. It is one of the most fiery-looking variables on our list — fiery in every stage from maximum to minimum, and is really a fine telescopic object in a dark sky, about the time of greatest brilliancy, when its colour forms a striking contrast with the steady white light of the sixth magnitude, a little to the north.

" 1857, *May* 7."

On the Variable Star U *Geminorum.* By Norman Pogson, Esq.

(*Communicated by Dr. Lee.*)

Within the last three weeks this remarkable object has again shone forth, reached a maximum, and vanished, most probably to be seen no more till October, when its reappearance and sudden changes may be next looked for. In general, it may not be worth while to publish the separate comparisons of a variable star, but in this instance it is better to do so, that observers may judge for themselves of the dependence to be placed upon the epoch and period of a star so difficult to catch, and which has not been seen more than twelve times, on the occasions of three of the five maxima which must have past since the star was first discovered by Mr. Hind, in December 1855. U *Geminorum* is of a pale bluish white tint when near maximum; never ruddy; but at the first reappearance after discovery a curious scintillation or twinkling was remarked about the third day after maximum, which could not arise from atmospheric disturbances, as neighbouring smaller stars were not similarly affected. Including Mr. Hind's first estimates the following are all the observations hitherto obtained :—

1855, Dec.	15	9·0 mag.	1857, April	8	9·7 mag.
	18	9·3		11	9·5
1856, March	26	9·6		14	10·8
	27	10·2		15	11·4
	29	11·0		16	12·1
1857, April	7	9·7		18	13·6

With the aid of the light-curve obtained by projecting the last seven observations on cross-ruled paper, so as to get some idea of its march, we may fairly adopt, as the three most probable times of maxima, the midnights of—

1855, Dec. 16
1856, March 24
1857, April 10

These dates give the first or chief epoch 1855, Dec. 17, and period 96 days. On the following evenings U *Geminorum* was

Digitized by Google

invisible, and therefore under the limits which, with due regard to the aperture and telescope employed, also with allowance for the state of atmosphere as shown by the appearance of the comparison stars, I have felt justified in assigning,—

1856, Jan. 2	Under 12 mag.	1856, Dec. 15	Under 12 mag.
12	13·5	24	11
27	11	27	13
April 2	13·5	29	13·5
4	13	1857, Jan. 14	13
10	12	15	13·5
12	11·7	16	13·5
16	12·5	27	13·5
20	11	29	13·5
24	13·5	31	13·5
May 10	13·5	Feb. 13	13·5
13	11·3	14	13·5
20	11·3	16	13·5
22	13·5	20	13·5
Sept. 3	10·7	23	13·5
Oct. 21	11	26	13·5
25	11.	28	13·5
Nov. 5	11	Mar. 3	12
8	11	4	13
14	11	12	13·5
26	13·5	13	13
29	13·5	17	13·5
Dec. 1	13·5	20	13·5

The negative evidence afforded by the above list, combined with the observations previously considered, warrants the belief that the period thus found is pretty near the truth, and not a multiple of a shorter period, as on the supposition of any aliquot part of 96 days we find a maximum due on one or other of the recorded times of invisibility. On the other hand, no maximum calculated from the deduced elements is contradicted by this list. Mr. Hind has informed me that his observation on Jan. 10, 1856 (R.A.S. *Monthly Notices*, vol. xvi. p. 56), when U *Geminorum* was estimated of the 12th magnitude, referred most probably to one of the many adjacent small stars, and not to the variable. It is also quite possible that in the cloudy interval between 1856, Dec. 29, and 1857, Jan. 14, a maximum escaped observation. The next, due on July 15, will be lost in the daylight; but the following one, due Oct. 19, may be observed in the mornings should the fortnight of visibility prove favourable; and it is hardly necessary to suggest how highly desirable a comparison of the light-curves obtained by independent observers, with different-sized telescopes, would prove, as a safeguard against that involuntary mental pre-occupation

Digitized by Google

which even the long experienced are well aware they cannot entirely get rid of.

Subjoined are my adopted magnitudes of convenient comparison stars, each of which is the mean of estimates taken on twenty *really* fine nights. My scale of magnitudes, which is merely Argelander's extended, has been sufficiently defined in the remarks appended to my ephemeris of the magnitudes of the minor planets, in the first number of this present volume:—

Star.	Mag.	1860. R.A. h m s	N.P.D. ° ′
a	8·8	7 46 52	67 58
b	9·3	7 48 6	67 48
c	9·3	7 48 14	67 46
d	10·3	7 45 41	67 24
e	11·0	7 46 19	67 48
f	11·3	7 46 48	67 32
g	12·1	7 47 4	67 38
h	12·4	7 46 52	67 34
U Gem. Var.		7 46·48	67 38

Hartwell House, April 23.

Observations of the New Planet Ariadne, taken at the Radcliffe Observatory, Oxford, with the Ten-feet Equatorial and Ring Micrometer. By Norman Pogson.

(*Communicated by M. J. Johnson, Esq., Radcliffe Observer.*)

1857.	G.M.T. h m s	Mag.	App. R.A. h m s	Log. $p \times \Delta$	App. N.P.D. ° ′ ″	Log. $q \times \Delta$	Comps.	Star.
April 15	13 34 14	9·4	13 30 19·96	+9·172	105 43 2·5	−0·891	5	*g*
	13 57 12	...	30 18·98	+9·259	42 56·7	−0·887	5	*g*
	15 24 31	...	30 15·26	+9·460	42 36·3	−0·867	3	*g*
16	12 5 4	9·2	29 24·24	+8·247	36 41·7	−0·897	6	*f*
	12 46 59	...	29 22·45	+8·927	36 32·8	−0·895	5	*f*
17	11 23 36	...	28 26·49	−8·620	30 11·2	−0·897	6	*g*
	11 35 33	...	28 25·98	−8·352	30 8·0	−0·897	6	*g*
18	12 2 17	9·3	27 25·04	+8·461	23 1·4	−0·897	5	*f*
	12 10 58	...	27 24·82	+8·636	23 0·0	−0·896	4	*f*
28	11 48 40	9·4	17 55·99	+8·924	104 10 0·3	−0·891	6	*e*
	12 12 47	...	17 55·13	+9·082	9 50·7	−0·889	6	*e*
May 2	11 45 48	10·1	14 35·40	+9·041	103 40 25·7	−0·888	6	*d*
4	12 32 47	...	13 1·70	+9·280	25 38·8	−0·880	6	*d*
5	12 50 51	...	12 17·52	+9·344	18 37·3	−0·876	8	*b*
6	11 53 59	...	(11 38·05)	+9·271	11 59·6	−0·883	9	*a*
	11 56 24	...	13 11 37·02	+9·184	103 11 57·9	−0·883	7	*c*

Digitized by Google

The observations have been corrected for refraction and motion as usual. The name *Ariadne* has been selected for the new planet, and will, it is hoped, receive the approbation of astronomers. The first R.A. on May 6 is probably one second too great. The comparison star (*a*) rests solely upon the authority of Lalande; and it appears that several, if not most of the stars on page 157 of the *Histoire Céleste* are one second too great in R.A. This consideration has also led me to reject the R.A. of the star (*b*) 24558 Lalande, which was one second greater than 24557 Lalande (*Histoire Céleste*, page 160), or Weisse XIII. 91 reduced to the same epoch.

The adopted mean places for 1857·0 of the comparison-stars, and their authorities, were as follow:—

Star.	Authority.	Mag.	Mean R.A.	Mean N.P.D.
			h m s	° ′ ″
a	Lalande 24488	7	13 3 50·59	103 11 53·4
b	Lalande 24557 and 8; W. XIII. 91	8	13 6 36·69	103 31 24·6
c	Ten microm. comps. with *b*	9	13 10 22·41	103 19 2·8
d	Lalande 24769; W. XIII. 230	7·8	13 14 30·80	103 40 2·3
e	Weisse XIII. 251	8	13 16 3·88	104 21 58·2
f	Argel. Zone 376, 192	8	13 26 59·54	105 35 15·2
g	A. Z. 296·4, 298·4, and 376·194	7·8	13 29 22·04	105 42 54·6

Occultation of Spica Virginis. 1857, *May* 6.

Highbury. T. W. Burr, Esq.

Emersion at $10^h\ 29^m\ 21^s{\cdot}6$, local sidereal time.

"The immersion was not seen, owing to the haziness of the atmosphere at the eastern horizon, and the bright sunshine. At the emersion, there was a decided adhesion of the star to the Moon's limb for more than a second; *Spica* appearing to emerge more in the leisurely manner of *Jupiter's* satellites in January last, than instantaneously, as the stars usually do. The definition was very good, and the time noted is that of the earliest visibility. Telescope 4ft. 4in., focal length, $3\frac{3}{8}$ inches aperture. Power 60."

Upper Tulse Hill. W. Huggins, Esq.

	h	m	s	
Immersion	9	28	54	} Local sidereal time.
Emersion	10	29	3·5	

"The moon and star very well defined. Both disappearance and reappearance apparently instantaneous and quite normal. Telescope 5-feet focal length, 5-inches aperture. Power 35."

Digitized by Google

On the Zodiacal Light. By Professor C. Piazzi Smyth.

(*Communicated by Admiral W. H. Smyth.*)

New theoretical views of the nature of the zodiacal light have lately been published, making it geocentric in place of heliocentric; they have been prominently published in the Astronomical Society's *Monthly Notices* for November, 1855, as results of observations by the Rev. George Jones, U. S. frigate Mississippi. Humboldt has there approved of them, and the Abbé Moigno, in his journal *Cosmos*, vol. viii. livraison 2, says, "that the idea had already come to many minds, and that he had long caressed it himself."

That an astronomical theory, based on the measures of observers of many nations during two centuries, should be suddenly *bouleversée*, is, in these days, rare indeed; and not only in this case is the old hypothesis, or rather conclusion, overset; but the new and promising "dynamical theory of heat" is deprived of the most brilliant of its achievements, viz., the explanation of the origin of the light and heat of the sun.

These considerations are not, however, for a moment to prevent our giving full attention to results fairly deduced from good observations; but before adopting ideas subversive of all previous notions, it may be well to examine the degree of excellence of the newly-collected facts. Now, though Mr. Jones appears to have been a very zealous and methodical observer, the circumstances which he was in were by no means the most favourable; for he was sailing all the time in his ship at sea, and therefore had always the maximum depth of the atmosphere to look through; while the faintness of the phenomenon in question is such, that it can never be fairly and certainly viewed, without first eliminating the lower and grosser part of the atmosphere. Having myself enjoyed unusual opportunities for effecting this desirable consummation by a continued residence of months on many mountain-tops both in North and South Africa, and having made instrumental as well as ocular observation of the zodiacal light a special object of pursuit, I will compare the results of Mr. Jones's sea-level observations with my own obtained at great heights in the atmosphere. My South African observations have been published in the *Transactions* of the Royal Society of Edinburgh, vol. xx.; and the North African in the Report on the Expedition to Teneriffe in 1856 (in the *Philosophical Transactions* for 1857?).

Mr. Jones says that he grounds his geocentric hypothesis, 1stly, on having seen at *midnight* two zodiacal lights, east and west.

This I have never seen, even in the clear air of 11,000 feet in altitude; there the zodiacal light clearly set in the western sky *three* hours before midnight, at midnight nothing was visible; at 1 A.M. there was a suspicion of something rising in the east; and

Digitized by Google

at 2 A.M., and afterwards, it was confirmed. The light in the east at that season of the year rose at a greater angle to the horizon than the other, and was some 13° longer, which accounts for its being seen within a less distance of midnight.

2dly. On the great lateral changes of the light, hour by hour, and *even half-hour.*

These were not seen at great heights in the atmosphere, and might easily be superinduced to an observer at the level of the sea, by moving haze, or fatigued eye, extraneous lights, &c. &c.

3dly. On having seen a lunar zodiacal light. An appearance of this sort I also observed on the Peak of Teneriffe, but measures of its angle with the horizon and consideration of the time and circumstances of its appearance, showed that it was not a zodiacal light, but the representative, in the lunar dawn, of the high-rising pink blush which precedes the solar day in a clear sky; and it was also shown that the lunar zodiacal light, according to the geocentric hypothesis, must be so very much fainter than the cone of the lunar dawn, as to be perfectly invisible to the human eye.

The most remarkable, however, of all the statements of the Rev. G. Jones, and one whereon may well rest the whole question between the geocentric and heliocentric hypotheses, is that one which is contained towards the conclusion of his paper; and is no less than "that when his ship sailed to the south of the Equator, the zodiacal light accompanied them, going southwards amongst the stars, and *vice versâ*, in a northerly cruise."

In reference to this point, I have examined the numerical measures of the right ascension and declination of the light, made by me on the Hottentot's Holland Sniew Kop, at a height of 4500 feet, in South Africa, with the similar observations for the same season of the year on Mount Guajara, in Teneriffe, at a height of 8903 feet, both stations, therefore, unexceptional for clearness of atmosphere; and I find the places given in the sky identical, notwithstanding a difference of 62° in the latitudes of the two mountains. When to this I add, that in the spring, at the Cape, in latitude S. 34°, the zodiacal light was always seen tending up to those same *Pleiades*, to which it may be seen invariably stretching at the same season of the year in this country, though the latitude is N. 56°, I cannot but suspect that the observations of the Rev. G. Jones in the U. S. frigate Mississippi apply to something which is not zodiacal light at all.

An Account of an Experiment on the Sun's Actinic Power, made by J. J. Waterston, Esq.

"The following is an account of an experiment I made in Bombay, in November 1855, on the limit of photographic power

Digitized by Google

of the Sun's direct light. It was made with the view of obtaining data in an inquiry as to the possibility of measuring the diameter of the Sun to a very minute fraction of a second by combining photography with the principle of the electric telegraph: the first being employed to measure the element space, the latter the element time. The result is, that about one twenty-thousandth of a second is sufficient exposure to the direct light of the Sun to obtain a distinct mark on a sensitive collodion plate, when developed by the usual processes.

"A circular wooden disk 19 inches diameter, and half-an-inch thick, was mounted on an iron axis, so that it revolved easily by an impulse given by pressing the finger with a jerk on the outer edge.

"About half-an-inch from the rim there was a circular aperture half-an-inch diameter, at the back of which the black paper was pasted. This paper was perforated by a needle, leaving a hole $\frac{1}{60}$-inch diameter. It was found that the utmost velocity that could be given to the disk was five revolutions in a second; and after four seconds, it was reduced to three revolutions per second. At each revolution the space described by the hole was about 50 inches.

"The revolving disk was placed behind the folding-doors of a darkened chamber, so that when one wing was opened to the extent of a few inches, the Sun's light struck the disk at the lower part of its revolution. Having made the preliminary arrangements, the observation was as follows:—

"First, the maximum rotatory motion was given to the disk. A prepared sensitive plate was held close behind the disk (about $\frac{1}{4}$-inch from it), at the part where the sunshine struck. This plate was kept slowly moving in the direction of the radius of the disk. An assistant quickly opened and shut the door, allowing the sunshine to act for about a second. The latent image on the plate being developed, was found to consist of four or five concentric lines. This was repeated several times with different plates.

"Taking the velocity of the aperture to be 150 inches per second, which is certainly under the mark, and the breadth of the hole $\frac{1}{60}$th of an inch, the duration of the Sun's full action on any one point must have been about $\frac{1}{9000}$th of a second.

"The photographic process employed was as follows:—

"'Albumen on glass iodized by tincture of iodine, 20 gr. to 1 oz. of spirit.

"'The silver bath, 50 gr. nitrate of silver to 1 oz. water, and 12 drops nitric acid.

"'The developing solution 3 parts water to one of acetic acid, and the mixture nearly saturated with protosulphate of iron.'

"The above was afterwards tried comparatively with the collodion process, and found to be considerably inferior in quickness of taking an impression, the ratio being 2 or 3 to 1."

Digitized by Google

Extracts from a Communication to Admiral Manners from Prof. Secchi.

The paper refers principally to the physical phenomena of the planet *Mars*, as observed with powers of 300, 600, and 1000, applied to the great refractor by Merz at the observatory of the Roman College.

On various days in the month of April of the present year, Prof. Secchi has watched with great attention the changes of appearance and position of the white spots about the poles of the planet, and has become strongly impressed with the view that much remains to be investigated respecting them. Others besides himself have perceived that these white patches are not situated diametrically opposite to each other: but Prof. Secchi thinks he has grounds for asserting that the axis of rotation passes very nearly centrally through the apparent lower or north polar region, and that the eccentricity attaches almost wholly to the apparent upper or south one.

On the 3d of April at $12^h\ 50^m$ Sid. time, the diameter of *Mars*, measured in the direction $191^\circ{\cdot}4$, which was that of the polar spots, was found to be

$$= 16''{\cdot}201$$

On April the 7th, after ascertaining the angle of direction of the chord passing through the two polar spots, the following measures were taken:—

Wire on the right limb	$31^p{\cdot}865$		
		$0^p{\cdot}440$	
— on line of spots	$32{\cdot}306$	$0^p{\cdot}160 = 2''{\cdot}474$	
		$0{\cdot}600$	
— on the left limb	$32{\cdot}905$		

Diameter $1{\cdot}040 = 16''{\cdot}084$

Whence the chord joining the spots subtended an angle of 162° $18'$, and passed at a distance from the centre of $0{\cdot}15$ of the radius. Taking the north patch to be concentric with the axis of rotation, it follows that the southern one must be eccentric by $17^\circ\ 42'$.

In confirmation of this opinion it is noted that upon April the 19th, the apparent upper or southern spot was seen inclined in the opposite direction to that which it had on the 7th.

Three series of measures of angle of position and distance between *Mars* and B.A.C. 4237, are next given in the paper.

Three very well-executed drawings of the disk of *Jupiter*, and one of *Venus*, were presented to the Society by Prof. Secchi, accompanied by a letter containing a few remarks upon them.

A volume was also received, entitled *Memorie del Nuovo Osservatorio del Collegio Romano*, anno 1852-1855, containing plans of the new observatory, and observations of double stars, nebulæ, the planets *Mars*, *Jupiter*, and *Saturn*, solar spots, and various comets, taken with the Merz refractor.

Digitized by Google

On the Means which will be available for correcting the Measure of the Sun's Distance, in the next twenty-five Years. By the **Astronomer Royal.**

At the Meeting of the Society, on the 8th of April, the Astronomer Royal gave an oral statement "on the means which will be available for correcting the measure of the Sun's distance in the next twenty-five years;" the substance of which is contained in the following abstract.

The members of the Society will not be surprised at our looking so far in advance as twenty-five years. The special opportunity, which will then present itself, is the last which will occur for nearly a century and half from the present time. Some years of preparation will be required to enable us to secure the full advantages which may then be within our reach. But, with all possible care, it will be found that the risk of total failure is not inconsiderable. The recognition of this danger naturally leads us to examine whether there will not be some earlier opportunity, of a different kind, for arriving at the same determination. And it will appear (in the judgment of the Astronomer Royal) that circumstances will be favourable, in the course of a few years, for obtaining a very good measure by the use of a different principle; less accurate, undoubtedly, in each of its individual applications than the method upon which reliance has usually been placed, but admitting of almost indefinite repetition, demanding no co-operation of distant observers, and requiring only that, in each instance, the observations which are to be compared be made with the same instrument and by the same observer (or with observers only so far changed that any personal equation would correct itself). But even this method requires appliances, which cannot be constructed at the moment of observation; and it is necessary to study well, some time before the operations shall actually commence, what equipment, instrumental and literary, is desirable for giving the best chance of success. It will appear that we are not beginning too soon to direct our attention to these matters in the present year.

The measure of the Sun's distance has always been considered the noblest problem in astronomy. One reason for this estimation is, that it must be commenced as a new step in measures. It is easy to measure a base-line a few miles long upon this Earth, and easy to make a few geodetic surveys, and easy to infer from them the dimensions of the Earth with great accuracy; and, taking these dimensions as a base common to every subsequent measure, it is easy to measure the distance of the Moon with trifling uncertainty. But the measure of the Moon's distance in no degree aids in the measure of the Sun's distance, which must be undertaken as a totally independent operation. A second reason is that, in whatever way we attack the problem, it will require all our care and all our ingenuity, as well as the application of almost all our knowledge of the antecedent facts of astronomy, to give the

Digitized by Google

smallest chance of an accurate result. A third reason is, that upon this measure depends every measure in astronomy beyond the Moon; the distance and dimensions of the Sun and every planet and satellite, and the distances of those stars whose parallaxes are approximately known.

The received measure of the Sun's distance depends on the transits of *Venus* of 1761 and 1769, but mainly on the latter. Very careful discussions of these will be found in the two books published by Encke, and in a memoir of great value by Don Joachim Ferrers, printed in our own *Memoirs*. On examining these, it will be found that, though there is very close accordance in the results obtained by the different investigators and from the different transits, yet all investigators have expressed their doubts upon those results. In the transit of 1761, the result depended almost entirely upon an accurate knowledge of the differences of longitude of very distant stations, which are undoubtedly subject to great uncertainty. In the transit of 1769 it happened that the result depended almost entirely upon the observations made by Father Hell at Wardhoe; and to these great suspicion has attached, many astronomers having, without hesitation, designated them as forgeries. It is evidently desirable to repeat the practical investigation when opportunity shall present itself.

It is desirable, for clearness, to begin with a reference to the simplest operation for measuring distance by parallax; as applied, for instance, to the Moon. In figure 1, let A and B be two observatories on the same meridian; and at A let the star C be observed to touch the Moon's limb, and at B let the star D be observed to touch the limb. (It will readily be understood that it is not essential that the observatories should be on the same meridian; if, as is in fact true, the Moon's apparent change of place can be exactly computed; nor is it necessary that the star touch the limb, if its angular distance can be very exactly measured.) After communication of the observations, the observer at A can measure the angle CAD. This angle differs from AMB by the angle ADB; but such is the distance of the stars, that the angle ADB is in every case unmeasurably small; and AMB, therefore, is to be taken as equal to CAD. Now, the dimensions of the Earth being known, the length and direction of the line AB will be known; and the directions of AM, BM, are known; and therefore the length of AM, BM, or of any other line drawn from M to any other part of the Earth, is easily found. A small error in the angle at M, that is, in the angle CAD, will produce a great error in the result for AM or BM. With this caution the problem is completely solved.

The question naturally rises, Cannot the same method be applied to the Sun? Practically, it cannot, for the following reasons. First, if errors of equal amount were committed in determining the inclination of the two lines AM, BM, for the Sun and for the Moon, their effects on the results would be enormously unequal. Thus, if the error were 2″, it would produce an error

Digitized by Google

of 100 miles in the Moon's distance; but it would produce an error of 16,000,000 miles in the Sun's distance. Secondly, no stars can be seen for observation in apparent contact with the Sun's limb. Thirdly, if for want of observable stars we rely upon the instrumental measure of the angular elevation of the Sun's limb, we introduce the risk of instrumental errors, and (far worse) of errors in the computation of atmospheric refraction at the most unfavourable of all times of observation; and these are sufficient completely to vitiate the method.

In consequence of these difficulties, astronomers have always sought to determine the distance of the Sun indirectly, by determining the distance of a planet, either by referring the planet's apparent place to stars, or by referring it to the Sun. In order to make this indirect process available, it is necessary to rely upon the *antecedent* determination of the *proportion* of the distances of the different planets from the Sun.

It is a historical fact that, in the time of Copernicus and Keppler, when astronomers did not know whether the Sun's distance from the Earth was nearer to ten millions or to a hundred millions of miles, the *proportion* of the distances of the different planets was known almost as exactly as at present. The first and rudest means of obtaining these proportions may be understood from figure 2. Commence with the assumption that the planets move in circular orbits. At the Earth E, the apparent angle S E V between the Sun and *Venus* reaches, but does not overpass, a certain value. At this time, then, the angle E V S is a right angle. Therefore, in the triangle E V S two angles are known (namely, at E and at V), and therefore the proportions of the three sides can be found; and two of these sides are the distances of the Earth and *Venus* from the Sun. Again, conceive that from the Earth E′ the planet *Mars* is seen in the direction E′ M′. By an acquaintance with the movements of *Mars*, derived from the observations of many preceding years, it is known that his position, as seen from the Sun, is in the direction S M′. The angular difference between these two directions is the angle S M′ E′. Also we know the angle S E′ M′, the apparent angular distance of *Mars* from the Sun. Hence (as in the instance of *Venus*) we know two angles of the triangle S E′ M′, and therefore we know the proportion of its three sides, two of which are the distances of the Earth and *Mars* from the Sun. These, at first, are very rude determinations; but they aid materially in introducing more exact ones. It is found by degrees that some alteration must be made in the inferred mean distances of the planets from the Sun; it is found by degrees that this will not suffice, and that the supposition of different degrees of ellipticity and in different directions must be introduced; and at length, by infinite repetitions of the process of trial-and-error, of which scarcely a trace remains, except in the results, proportions of very considerable accuracy are obtained. In all this there is not the smallest reference to any of the absolute distances.

Digitized by Google

In figure 3 is shown the first practical inference from this knowledge of proportion of distances, as applied to a transit of *Venus*. Let *Venus* V be so exactly between the Sun and the Earth that she can be seen upon the face of the Sun. An observer at A sees her upon the point S, and an observer at B sees her upon the point S′. Suppose the relation between the points S and S′ to be such as to admit of record (the mode of making this record will be considered shortly), and suppose, by means of that record, the angle S A S′ is measured. The angle which we desire to obtain, in order to measure the Sun's distance, is A S′ B. Now the proportion of our measured angle S A S′ to the desired angle A S′ B is sensibly the same as the proportion of S′ V to A V, or as 72 : 28, very nearly. Thus it appears that we measure a large angle in order to infer from it a small one: and this is the circumstance which is the most favourable of all for obtaining an exact result. (If we tried to use a transit of *Mercury* in the same way, it would be found that the measured angle at A is to the required angle at S′ in the proportion of 4 to 6 nearly, that is, that we measure a small angle in order to infer from it a larger; hence the transits of *Mercury* are inapplicable to the measure of the Sun's distance.) It is further to be considered that in this reference of the apparent place of *Venus* to the disk of the Sun, no use is made of stars, and nothing depends on the difficulty of computing refraction, inasmuch as *Venus* and the Sun are, at the time of the observation, subject to the same refraction.

This method then appears likely to be excellent, provided that we possess a practical process for measuring the angle S A S′. The mode of finding this will be our next consideration.

In the central diagram of figure 5 is represented by a black line the path which *Venus* will appear to describe across the Sun's disk in the transit of 1882 (reversed in regard of right and left, for the convenience of subsequent investigations) as seen from the centre of the Earth. For the present let us lay aside the consideration of the Earth's rotation. An observer in the northern portion of the Earth will see *Venus* describe, not the black line, but the fainter line below the black line and parallel to it. An observer in the southern portion of the Earth will see *Venus* describe the fainter line above the black line. The path seen by the southern observer is longer than that seen by the northern observer, and therefore occupies a longer time. Consequently the mere observation of the duration of the transit at these two stations would give information on the lengths of the two chords, and therefore would give means of computing the amount of separation of the two chords: and this apparent separation corresponds to the angle S A S′ in figure 3. We have therefore all the means of computing the angle A S′ B, and of inferring from it the Sun's distance: although, as may be imagined, the intervening calculations are sufficiently complicated.

But this is on the supposition that the Earth has no motion of

Digitized by Google

rotation. Let us introduce the consideration of rotation, and see how it modifies the result.

In the right-hand diagram of figure 5 is represented the face of the Earth, which is turned towards the Sun at the ingress of *Venus* on the Sun's disk; and in the left-hand diagram of the same is the face which is turned towards the Sun at the egress. The reversed form given to the solar disk in the central diagram refers all lines of the three diagrams to corresponding geometrical direction. Now, fixing our attention on a northern station, in the United States of America for instance, it will be seen that the translation of this place by the movement of rotation carries it to meet the motion of *Venus*. Consequently it tends to shorten the duration of the transit. But by virtue of the northerly position of that station, the duration of transit is already shortened. Consequently, by combination of these two effects, the duration of the transit at the northern station is very much shortened.

Now can we select a southern station such that the same rotation of the earth shall tend to lengthen the duration of transit as seen there? The transit at southern stations is already the longer by virtue of their southern position: and if to this we could superadd a further lengthening by virtue of the Earth's rotation, we should have a very long duration of transit there which we might hope to compare with the very short duration at the north station, with the prospect of obtaining a combination which would be most advantageous for obtaining the measure sought.

We can select such a station.

It is essential to remark that the transit will take place in the month of December, and that at that time the Earth's south pole will be turned towards the Sun, and therefore that those regions of the Earth which are included between the south pole and the southern limit of illumination will be carried by rotation in a direction opposite to the direction of movement of all the northern parts of the Earth. If we fix our attention on a small darkly-shaded part of the Antarctic Continent; and if we compare its positions in the right-hand diagram and the left-hand diagram, it will be seen that it is carried in the same direction as *Venus*, that the apparent movement of *Venus* is therefore made slower, and that the duration of transit is thereby lengthened. And as it is lengthened already by the southern position of the station, it will by the combination of these causes be very much lengthened. Comparing this with the observed duration in the United States, where it is very much shortened, we shall have a large difference, depending entirely upon the proportion which the Earth's radius bears to the distance of the Sun, and most favourably available for the determination of that proportion. The difference of the times of duration would probably be not less than twenty-five minutes.

Thus the circumstances of the transit of 1882 are peculiarly favourable (subject only to certain practical considerations, to be noticed hereafter,) for the determination of the proportion of the

Digitized by Google

Earth's radius to the Sun's distance (usually called the Sun's horizontal parallax, or more strictly the sine of the Sun's horizontal parallax). A discussion of the transit of 1874 will show what are the conditions on which this favourable state depends.

In figure 4, where *Venus* is seen crossing the northern part of the Sun's disk, it will be perceived that the northern station has (independently of the Earth's rotation) the longer duration of transit, and the southern has the shorter. Now when we introduce the consideration of rotation, no selection of stations on the principle adopted for 1882 will tend to exaggerate this difference. If both stations are on the north side of the south pole, the movement of rotation shortens both durations in no very unequal degrees. If we take a station between the south pole and the southern limit of illumination, the motion of rotation tends to lengthen the duration which by virtue of southernly position is shorter, and thereby the inequality is diminished. Thus it appears that the transit of 1874 cannot be used with the same advantage as that of 1882 for determining the Sun's horizontal parallax.

An examination of the characteristics of these transits, and also of those which occur in the month of June (as 1761 and 1769) when the north pole of the Earth is turned towards the Sun, suggests the following remarks. The transits favourable for the determination of the Sun's horizontal parallax are those in which the part of the Sun's disk crossed by *Venus* has the same name (north or south) as the pole of the Earth which is turned towards the Sun. Now in general (but not always) the transits of *Venus* will occur in pairs (as 1761–1769, 1874–1882), with an interval, in each case, of eight years. This interval depends on the circumstances that the transits can only be visible when the conjunction of the Earth and *Venus* takes place very near to one of the nodes of the orbit of *Venus* on that of the Earth; and that in eight years *Venus* has revolved almost exactly thirteen times, so that a conjunction at any one degree of heliocentric longitude is followed by a conjunction very near to the same degree after an interval of eight years. But in consequence of the proportion of 8 : 13 being not quite exact, and because in eight years *Venus* revolves a little more than thirteen times, the successive conjunctions take place in 2¼ days *less* than 8 Julian years. Therefore at the second conjunction *Venus* is less advanced in respect of the node than at the first. At the December conjunctions *Venus* is near the ascending node, at the June conjunctions she is near the descending node. In the former, therefore, she will be at the second transit more southerly, and in the latter more northerly, than at the first transit. These indications correspond with those of favourable transits. Therefore in all cases the second transit of each pair is the more favourable for determining the Sun's horizontal parallax. The exceptional case is when *Venus* crosses the middle of the Sun's disk, as then the latitude of *Venus* is too great at both the next preceding and the next following 8-year interval to give a visible transit.

Digitized by Google

In the explanation up to this point, we have gone on the supposition that the observations of transit to be employed are those of duration of transit. And this method possesses the very important advantage, that it is entirely independent of the assumed longitude of the place of observation. But there is another method, namely, that of observing the absolute time (as referred to Greenwich time) of ingress only or of egress only, at different stations on the Earth. The best way of considering this is to conceive that figure 3 is not in the plane of a meridian, but in the plane passing through the observing-station and through the Earth's centre. Then it is plain that the apparent disturbance of the point S from the point at which *Venus* would be seen from the Earth's centre, is in the plane which passes through the observing-station and through the Earth's centre. Now if this plane is parallel to the Sun's limb at the point of ingress, the disturbance of the apparent place of *Venus* will merely cause its place to slide along the Sun's limb, and will not affect the time of ingress. If the plane is perpendicular to the Sun's limb at the point of ingress, the disturbance will tend to throw *Venus* upon or off the Sun's disk in the greatest possible degree, and therefore to accelerate or retard the ingress in the greatest possible degree. But the observed time of ingress must necessarily be expressed, in the first instance, in local time; this can be converted into Greenwich time only by application of the assumed longitude of the place, and therefore when we compare the Greenwich times of ingress as observed at two stations, the result is necessarily affected by the possible errors of two longitudes. The same remarks apply to the egress.

We are now in a state to consider the applicability of the two methods to the transits of *Venus* in 1874 and 1882. The calculations of the places of the Earth and *Venus*, upon which the diagrams of figure 4 and figure 5 are founded, have been made by Mr. Breen, Assistant to the Royal Observatory, and may be accepted as accurate. At the commencement of this evening's meeting, an independent set of calculations was handed to the Astronomer Royal by Mr. Hind, Superintendent of the Nautical Almanac, which do not sensibly differ from Mr. Breen's. In the exhibitions of the illuminated side of the Earth, the nearest integral hour of Greenwich mean time is taken, because (as will be mentioned) there is yet a little uncertainty on the exact time.

First. On the application of the method of difference of duration of transit to the transit of 1874.

It has already been remarked that in this transit there is no possibility of combining the effect of Earth's rotation with the effect of difference of latitude of stations, so as to exaggerate the difference of durations of transit depending on difference of latitude alone. And if we consider the effect of difference of latitude only, we find that circumstances are not very favourable. The most northerly stations are to be found in Siberia, Tartary, and Thibet (which will scarcely be visited by astronomers in December), on the coasts

Digitized by Google

of China, and in North British India. The most southerly stations will be Kerguelen's Island, Van Dieman's Land, and New Zealand. But the observable difference of duration will probably not be half of that in 1882.

Second. On the application of the method of the difference of absolute times to the transit of 1874.

For the ingress, favourable positions will be found at Owhyhee (where the displacement tends to throw *Venus* upon the Sun's disk, or to accelerate the ingress), and at Bourbon, Mauritius, and Kerguelen's Island (where the displacement tends to throw *Venus* from the Sun's limb, or to retard the ingress). For the egress, Sicily, Italy, and portions of Europe west of the Black Sea, are so situate as to throw *Venus* upon the Sun's disk, or to retard the egress; and New Zealand, New Caledonia, Van Dieman's Land, and Eastern Australia, are well situated for accelerating the egress. But it is doubtful whether the longitudes of any of the stations named, except those in Europe, are yet known with sufficient accuracy.

Third. On the application of the method of difference of duration of transits to the transit of 1882.

It has been already pointed out that there are two tracts, each sufficient to contain a number of observing stations, which are particularly well adapted to these observations. And it is specially to be remarked that the command of a number of stations, sufficiently near together to see the astronomical phenomenon in nearly the same way, but sufficiently separated to take the chances of different states of the sky, is very important. On occasion of the eclipse of 1842, the astronomers at Turin saw nothing, in consequence of the cloudy state of their sky, while the Astronomer Royal on the Superga, not five miles distant in a straight line, saw all the phenomena of the eclipse. Bearing this caution in mind, we will consider the circumstances of the two tracts in question.

The northern tract includes the whole of the United States of North America. The observatories are numerous, and they possess an advantage which even yet is little known in Europe: namely, that from the extent of galvanic telegraph, the habit of using it in the United States, the public spirit of the nation and of the telegraph-companies, which would assuredly induce them to devote that wonderful auxiliary to the exclusive use of astronomy on an occasion so important, and the absence of political suspicions, all the observing-stations would for an observation like this be connected by the galvanic telegraph. (The Astronomer Royal adverts to the political suspicions, not without some bitterness, for he has been prevented by them from using a European telegraph for a single hour to determine the longitude of an important continental point.) The peculiar advantage of connecting, at least of comparing, all the observers' clocks, would be of this kind. Suppose that there were ten observing-stations, and that, in consequence of the changeable weather, the ingress only was observed at five of

Digitized by Google

these stations, and the egress only at the other five. If the clocks of the observatories were not connected or compared, these observations would be totally lost. But if they are connected, then every observation is referred to the absolute time of one clock, say the Washington clock; and from a knowledge of the geographical position, a correction of the absolute time may be computed, so as to deduce, from every observation of absolute time of ingress at any station, what would have been the absolute time of ingress had it been observed at Washington, and from every observation of the absolute time of egress at any station, what would have been the absolute time of egress had it been observed at Washington; and thus we shall have five observations of ingress and five observations of egress, all as if they had been observed at Washington and noted by the Washington clock. Humanly speaking, therefore, we may say that the probabilities for the accurate and efficient observation of these phenomena in the United States are vastly superior to any that could have been reckoned on in any former time, or to any that could now be reckoned on in any other region.

The southern tract is a part of the Antarctic land discovered by Lieut. Wilkes of the U. S. Navy, included between Sabrina Land and Repulse Bay, and occupying an extent of about 400 miles. The Astronomer Royal is informed by General Sabine that the 6th of December is rather early in the season for a visit to this land, but probably not too early, more especially as firm ice will be quite as good for these observations as dry land. It must, however, be borne in mind that it is indispensable to secure observations both of ingress and of egress in this tract, without which all the advantages of the North American observations will be useless. For this purpose it appears absolutely necessary to establish a chain of observing-posts, and to furnish some means of comparing the clocks. We are in possession now of two powers, unknown in former times, applicable to this purpose. One is the galvanic telegraph, which possibly (but not very probably) might be laid down in a temporary way. The other is the use of steamers, by which the observers would be distributed to their several posts, and which would be constantly employed for some days before and some days after the transit, in running up and down the line of coast with a number of chronometers, and comparing them with the stationary chronometers at each observing-post. It would be extremely desirable that the country should be reconnoitred some years before the transit, in order to ascertain at a sufficiently early time the practicability of these or some equivalent plans, without which the risk of entire failure would be great.

Fourth. On the application of the method of the differences of absolute times to the transit of 1882.

For the ingress, the islands of Bourbon, Mauritius, and Kerguelen's Island, are very favourably situated for accelerating the ingress; and the United States of North America for retarding it. For the egress: Van Dieman's Land, Eastern Australia, New Zealand, and New Caledonia, will have the egress much retarded;

Digitized by Google

while the United States, the West India Islands, and the coast of South America as far as the Rio Plata, will have it accelerated.

In the transits of 1761 and 1769 great difficulty was found to attach to the observations of the internal contact of the limb of *Venus* with the Sun's limb, from the phenomenon which in late years has attracted attention under the name of Baily's beads. The Astronomer Royal expressed his opinion as entirely coinciding with that of Professor Powell, that this phenomenon is simply due to irradiation, as arising partly from diffraction, partly from fault of the telescope, and partly from the nervous excitement of the eye. From his own experience in two total eclipses of the Sun, in which he had taken great pains to see the phenomenon, and had (as he believes simply because he took care to see the Sun very distinctly) been unable to see the slightest trace of it, he had not the smallest doubt that, when proper care is taken for distinct vision, the phenomenon will not be seen at all. He referred specially to his delightful view of the very beautiful phenomenon of the disappearance of the last portion of the Sun in the valleys between the lunar mountains, in the eclipse of 1851; which with less distinct vision would probably have created strings and beads. This distinctness of vision he ascribed principally to the use of a graduated dark glass, constructed under his direction by Mr. Simms. It consists of a long wedge of red glass and a long wedge of green glass, their edges turned the same way, combined with an equivalent wedge of colourless glass, its edge turned the opposite way. Nobody would suppose without trial how fastidious the eye is as to the proper intensity of shade; and how distinctly, when intent on clear vision, it rejects a shade in the most trifling degree lighter or darker. He thought it highly important that such shades should be used for observing the transits of *Venus*. It is desirable also that the colour left by the shade-glass should be agreeable to the observer's eye.

Still there is one caution which must not be put out of sight. The selection of places depends entirely upon the portion of the Earth which is illuminated at the times of ingress and egress; and if the tables of the movements of *Venus* are erroneous in 1882 to the amount of an hour's motion, the illuminated face of the Earth will be altered to the amount of two or three hours' rotation of the Earth, and the selection of stations may be totally changed. It is, therefore, most important that the tables of *Venus* should be thoroughly examined, and where necessary rectified. A great mass of observations of *Venus* exist, already reduced so far as to require only the very last step of substitution of errors of planetary elements. The Astronomer Royal referred particularly to the Greenwich Planetary Reductions from 1750 to 1830, to the reduction of certain Cambridge observations, to the reduction (in the annual Greenwich volume) of the Greenwich observations down to the present time, and to the discussion of some of the Greenwich observations by Mr. Main and Mr. Glaisher. And he took the opportunity of expressing his opinion that fifty pounds spent on calcu-

Digitized by Google

lations with an object like this would confer much greater benefit on astronomy than a thousand pounds employed in the foundation and equipment of an observatory.

On viewing the expense and the risk of the determinations of the Sun's distance by transits of *Venus*, as well as the distance of time, which must necessarily place them beyond the knowledge of many observers of the present day, it appears natural to consider whether other methods cannot be used, less stringent as to the moment of observation, requiring less co-operation of observations, and occurring at an earlier time. Such are the direct determinations of the parallaxes of *Venus* and of *Mars*, when near to the Earth, by simultaneous observations at northern and southern stations as in figure 1, or by successive observations at the same observatory when it is brought to different positions by the Earth's rotation as in figure 6.

Venus cannot be compared with stars on the meridian. She may be compared with stars in extra-meridional observations before sunrise or after sunset, but she is then uncomfortably bright, and rarely well defined; and she has only one illuminated limb admitting of observation, and therefore in the comparison of observations made at different stations there is great risk of error from difference in the estimation of her semidiameter. Moreover she does not remain long in the position nearest to the Earth; and the nearer she is, the more contracted are the daily hours of observation. It seems unlikely that trustworthy results will be deduced from the observations of *Venus*.

The circumstances of *Mars* in opposition to the Sun (figure 6), are much more favourable. *Mars* may then be compared with stars through the whole night: he has two observable limbs, both admitting of good observation: he remains much longer in proximity to the Earth; and the nearer he is, the more extended are the hours of observation.

Here, however, a circumstance is to be considered which has not previously called for attention. The orbit of *Mars* is much more excentric than those of *Venus* and the Earth. At some oppositions, therefore, he will be so far from the Earth that little advantage will be derived from attempting to observe his parallax. (It is understood that such observations were made in the United States' expedition of a few years past, which, from the great distance of *Mars*, must have been nearly useless.) At other oppositions he is almost as near as *Venus* is about conjunction. The following table expresses roughly the distance of *Mars* from the Earth, at some of the nearest and some of the most distant oppositions. The unit of measure is the Earth's mean distance from the Sun:—

1860 about	July 21	0·38
1862	October 1	0·39
1869	February 13	0·68
1871	March 22	0·64
1877	September 3	0·37

Digitized by Google

The years 1860, 1862, and 1877, are therefore favourable for the determination of parallax. But they require the following special considerations.

When, as in figure 1, the method of comparison of observations made at a northern observatory and a southern observatory is employed, the most favourable position of the planet is that of verticality to the point midway between the two observatories. The north latitude of the northern observatories (Greenwich, Berlin, Pulkowa) is greater than the south latitude of the southern observatories (Cape of Good Hope, St. Jago). Hence, *cæteris paribus*, a north declination of *Mars* will be preferable to a south declination. In this respect the opposition of 1862 is preferable to that of 1860.

But there is another method of making observations for parallax, not applicable to *Venus*, but applicable to *Mars;* namely, by observing the displacement of *Mars* in right ascension, when he is far east of the meridian, and far west of the meridian, as seen at a single observatory. Thus, in figure 6, conceive the pole of the Earth to be turned towards the eye, and conceive the Earth and *Mars* to be stationary in space, the Earth however rotating round its axis. By the diurnal rotation, an observatory is carried from the position A to A′; and at one of these times *Mars* is seen in contact with one star, and at the other time with another star. These observations give the means, as in figure 1, of determining the distance of *Mars*. And though, in fact, both the Earth and *Mars* are moving, yet the effects of those motions can be so exactly calculated as to give to the determination the same accuracy as if both were at rest.

In order to compare the value of this method with that of observations on the meridian at two observatories, we must estimate the length of the base-line, AB in figure 1, or AA′ in figure 6. The greatest meridional base-line, from Pulkowa to the Cape of Good Hope, is = Earth's radius × 2 sine 47° nearly. The measure of the greatest base-line AA′ depends on the latitude of the observatory. At Greenwich it is = Earth's radius × 2 sine 38° 30′; at the Cape of Good Hope and at St. Jago (Chili) it is about = Earth's radius × 2 sine 57°; at Madras it is nearly = Earth's radius × 2 sine 77°. Thus it appears that at each of the three last-mentioned observatories, the base-line which can be obtained is considerably greater than the best which can be obtained by meridional combination of two observatories. At Madras, the angle to be measured would be about 44″. To this is to be added that the method is attended with no expense whatever; that the observations, which are compared, are made with the same telescope and by the same observer, or the same series of observers; that there is none of the tediousness, the wearying correspondence, or the doubt, which are inseparable from observations requiring distant co-operation; and that the observer is supported by the feeling that his own unassisted observations will give a perfect system of means for deciding one of the most important questions

Digitized by Google

in astronomy. The Astronomer Royal expressed his opinion that this method is the best of all.

In order to use the process to the greatest advantage, *Mars* ought to be visible at six hours' distance from the meridian on each side; and therefore his declination ought to have the same name as the latitude of the observatory. Thus, 1860 will be a favourable year for the Cape of Good Hope and St. Jago; 1862 will be favourable for North American and European observatories. It is scarcely necessary to discriminate between them for Madras, where both years are good; 1862, however, is preferable to 1860.

The first equipment for this observation, on the necessity for which special stress must be laid, is an equatorial, firm in right ascension. Many modern equatorials are deficient in this important quality. It would be well, in using them, to apply a temporary mechanism for fixing the instrument in right ascension, such as its construction may permit. The next, which will be found advantageous, though not strictly necessary, is the apparatus for the American or chronographic method of transits, by which the number of observations may be greatly increased, and something will be gained in the accuracy of each. These, with the ordinary clocks and chronometers, &c., of an observatory, are all that are required.

The principal rules for the observer would be: To make the observations as near as practicable to the six-hour intervals from the meridian, on both sides; and to repeat the observations in continued sequence, morning and evening, morning and evening. If different observers are employed, to take care that each observer is charged as often with morning as with evening observations. To determine the difference between the right ascension of *Mars* and the right ascensions of two stars, one having greater N.P.D., and the other smaller N.P.D. than *Mars*. To use the same stars in at least two observations of different names, morning and evening; and in as many more consecutive observations as can be conveniently arranged. When it becomes necessary to change the selection of stars, to observe both the old pair and the new pair in one morning or evening observation. In all cases to observe, by such alternation as is most agreeable to the observer, both limbs of *Mars* (the preceding and the following). The observations might with advantage commence a fortnight before opposition and terminate a fortnight after it.

In the nature of external preparation, applying generally to all observatories, the principal requisite is a chart of the apparent path of *Mars*, in considerable detail, giving the place of the planet for every hour or every few hours, and giving the places of all the stars, little and great, in its neighbourhood. The observer in possession of this will be able to select stars of such a magnitude as he judges most agreeable to his eye, and at such intervals as will be convenient for his system of wires; and to attend rigorously to the condition of always comparing the planet with two

Digitized by Google

stars, one of greater and one of less N.P.D. It might be proper that the colour of the stars should be noted, in order that, to avoid possible inequalities of refraction, stars of the same colour as *Mars* (if there are such) may be selected. It would not, perhaps, be too much to expect such charts for 1860 and 1862 from the superintendents of our national ephemerides.

On reviewing the whole subject, the Astronomer Royal presses on the attention of astronomers the importance of observing *Mars* in 1860 and 1862; and for this purpose, the necessity of speedily making the preparations, instrumental and literary, which he has described, especially that of the charts of stars with the path of *Mars*. At the same time he urges that the future astronomical public will not be satisfied, unless all practical use is made of the transits of *Venus* of 1874 and 1882; and that for these, a thorough discussion of the elements of the orbit of *Venus*, the determination of some distant longitudes, and a reconnaissance of Wilkes' Land, must be effected within a few years.

A copy of "Specimens of Tables, calculated, stereomoulded, and printed by Machinery," was laid upon the table. The machine, the work of the Messrs. Scheutz, father and son, is now the property of the Dudley Observatory, having been purchased and presented by J. F. Rathbone, Esq., of Albany, U. S.

In a preface of much interest, the origin of its first conception, the various vicissitudes experienced in its construction, and the means by which final success was attained, are related, with particular acknowledgment of the obligations of the inventors to the Baron von Wrede and different members of the Swedish Academy, and while in this country to W. Gravatt, Esq.

Mr. De La Rue exhibited finished engravings of the planets *Jupiter* and *Saturn*, the latter printed in colours, copies of which he most handsomely offers to Fellows of the Society, who may apply for them to the Assistant Secretary. Of the advantage of colour-printing, it may be permitted to retain a doubt; but of the beauty of the result obtained in the case of *Jupiter* it would be difficult to speak too strongly.

Fellows of the Society will do well to send for their copies in as many cases as possible, as they are of a size to be very liable to injury if forwarded through the post.

Digitized by Google

ERRATA.

Professor Powell's attention has been called to the following Errata in his paper which appeared in the *Monthly Notices* for March :—

Page 145,	Lowndes	*for*	$\frac{1}{12\cdot1}$	*read*	$\frac{1}{17\cdot3}$
	Dawes	—	$\frac{1}{12\cdot5}$	—	$\frac{1}{15\cdot0}$
	Grove	—	$\frac{1}{13\cdot4}$	—	$\frac{1}{15\cdot1}$
	Lord Wrottesley	—	$\frac{1}{14\cdot1}$	—	$\frac{1}{16\cdot6}$
	Webb	—	$\frac{1}{15\cdot2}$	—	$\frac{1}{17\cdot8}$
Page 147,	Chalmers	—	$\frac{1}{14\cdot4}$	—	$\frac{1}{15\cdot3}$

,, ,, also, *for* $3^{ft}\ 16^{in}$, *read* $3^{ft}\ 6^{in}$.

CONTENTS.

	Page
Greenwich Observations of Small Planets	197
Extract of a Letter from Mr. Johnson to the Astronomer Royal	199
Note on R *Leonis*, by Mr. Hind	ib.
Mr. Pogson on the Variable Star U *Geminorum*	200
Oxford Observations of the Planet *Ariadne*	202
Occultation of *Spica* on the 6th of May	203
Professor Smyth on the Zodiacal Light	204
Mr. Waterston on the Sun's Actinic Power	205
Extracts from a Communication from Professor Secchi	207
The Substance of a Lecture delivered before the Society on the 8th of April, by the Astronomer Royal, "On the Means which will be available for correcting the Measure of the Sun's Distance, in the next twenty-five Years"	208
Miscellaneous	221

London :—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, June 1, 1857.

Digitized by Google

Digitized by Google

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *June* 12, 1857. No. 8.

Rev. R. MAIN, Vice-President, in the Chair.

Charles Leeson Prince, Esq., Uckfield, Sussex;
Rev. Thomas W. Weare, Under-Master of Westminster School;
Charles Howell, Esq., Hove, near Brighton,

were balloted for and duly elected Fellows of the Society.

It was announced from the Chair that Miss Sheepshanks, of London Street, Reading, had presented to the Society all the astronomical and other scientific instruments which belonged to her late brother, the Reverend Richard Sheepshanks. This intelligence cannot fail to be gratifying, not merely to the personal friends of Mr. Sheepshanks, who cherish a lively remembrance of his many endearing qualities, but to all true lovers of astronomy throughout the country, who appreciate the unwearied devotion with which Mr. Sheepshanks laboured in promoting the interests of this Society. The intrinsic value of this munificent gift may be readily inferred from a recollection of the admirable judgment of Mr. Sheepshanks and his consummate skill in all that related to the theory and manipulation of instruments. It is scarcely necessary to add that the thanks of the Society were unanimously awarded to Miss Sheepshanks for these valuable and interesting memorials of her lamented relative.*

New Planet.

A new Planet (the forty-fourth of the minor planets) was discovered by M. Goldschmidt at Paris, on the 27th of May. The following positions were obtained by the discoverer:—

	M.T. Paris. h m	R.A. h m s	Decl. ° ′	
1857, May 27	11	15 15 58	−12 8	Merely approximate.
June 1	10 55	*a* − 3 53·8		

The star *a* is Lalande 28036. The planet resembles a star of the 10.11th magnitude. Two complete positions and elements of the planet will be found at page 253.

* A detailed list of the various instruments contained in this valuable collection will be given on a future occasion.— R. G.

Digitized by Google

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Month of May, 1857.

(*Communicated by the Astronomer Royal.*)

Ariadne.

(In continuation of those sent last Month.)

Mean Solar Time of Observation.				Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	°	′	″
1857, May 11	9	50	6·9	13	8	35·85	102	38	48·12
13	9	41	14·5	13	7	35·12	102	26	20·20
14	9	36	51·4	13	7	7·83	102	20	19·90
18	9	19	38·2	13	5	38·01	101	57	55·02
19	9	15	24·9	13	5	20·64	101	52	46·23

Iris.

Mean Solar Time of Observation.				Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	°	′	″
1857, May 4	10	28	2·7	13	19	1·95	104	59	35·17
5	10	23	22·0	13	18	17·08	104	53	5·89
6	10	18	42·4	13	17	33·25	104	46	40·19
7	10	14	3·6	13	16	50·29	104	40	19·12
8	10	9	26·3	13	16	8·76	104	34	1·17
11	9	55	40·5	13	14	10·36	104	15	32·11
13	9	46	36·2	13	12	57·65	104	3	37·32
14	9	42	5·8	13	12	23·09	103	57	47·28
18	9	24	17·5	13	10	18·14	103	35	22·95
19	9	19	53·6	13	9	50·04	103	30	3·81

May 13.—The observed place in R.A. agrees exactly with the Ephemeris, and that of N.P.D. does so after having been increased by 5′.

Lætitia.

Mean Solar Time of Observation.				Apparent R.A.			Apparent N.P.D.		
	h	m	s	h	m	s	°	′	″
1857, May 14	12	57	11·1	16	28	0·41	95	57	48·29
26	12	0	12·8	16	18	11·50	95	19	33·73
27	11	55	26·1	16	17	20·52	95	17	8·19

Digitized by Google

Observations on the Stars in the Nebula of Orion.

By Mr. Otto Struve.

(*Communicated by the Astronomer Royal.*)

"Being interested with the publication of M. Liapounov's paper on the nebula of *Orion* (*Monthly Notices*, March, 1856), I was induced last autumn to compare with the heavens the different catalogues of the stars situated in that nebula (Sir J. Herschel's, Lamont's, Bond's, and Liapounov's Catalogues), in order to ascertain the origin of certain discrepancies offered by them. The results of this investigation will be communicated to the astronomical world in a memoir that I am now preparing for publication, as an addition to that of M. Liapounov. But some results to which I was led will, I hope, appear to deserve the particular attention and future inquiry of astronomers established at stations more favourably situated for the observation of that object. For this reason I avail myself of this early opportunity to notify these observations to the Astronomical Society.

"Sir J. Herschel's Catalogue (no doubt the most complete, and at the same time the most systematically worked, that we possess) contains, in the *Regio Huygheniana*, besides the well-known 6 stars of the trapezium, 5 other small stars numbered by him 51, 57, 75, 78, and 88. When I first directed my attention to these stars, on the beautiful night of 1856, Oct. 30, I could well see all of them, excepting 78, that really appeared to be out of the reach of our refractor. The other four stars were estimated by me to be in the following order of brightness:—

88	magn.	12
51	,,	12, 13
75	,,	12, 13
57	,,	13

"It then immediately struck me that there was a sixth star *s*, nearer to the trapezium than any of the other stars, that appeared to have been overlooked by Herschel, if it has not been omitted by him for other reasons. On that night I estimated it brighter than 51, but not quite so bright as 88. By micrometrical measures I found its position with regard to *θ Orionis* $\Delta\alpha = -7''.3$, $\Delta\delta = -27''.6$.* On further inquiry it appeared that this star was not to be found in any of the other catalogues, excepting, perhaps, in that of Dr. Lamont, where a star (No. 28) is indicated approximately in the same direction from *θ*, but at somewhat too great a distance.

* It may be desirable to remark that this star *s* is different from the new star of M. Porro, mentioned elsewhere in the present number. The differences from *θ Orionis* of M. Porro's star are roughly $\Delta\alpha = -4''$, $\Delta\delta = -5''$.—[Editor.]

Digitized by Google

"Nine days later, on the 8th of November, *s* was hardly visible, while the other 4 stars remained nearly in the same order of brightness: however, it was still visible, and so it was Dec. 2; but at this date its brightness could by no means be estimated higher than 13·5, the extreme limit that I assign to stars visible with our refractor. Hence a variability of light was proved for this star.

"Afterwards, 1857, Jan. 20 and Feb. 21, no trace was to be seen of this star; but on March 1 it reappeared, and was estimated nearly as bright as 57. Bad weather prevented my continuing observations on the next following days until March 18. At this date *s* appeared in brightness between 88 and 51, but considerably nearer to 88; two days later, March 20, it was even brighter than 88. Since then it began to decrease. March 23, I found it nearer to 51 than to 57; March 24, it was certainly less bright than 57. Clouds prevented me from observing on the next following evenings; and when again the sky cleared up, the strong twilight had put an end to these observations.

"Starting from the magnitudes assigned above to the four comparison stars, we have therefore the following reduced magnitudes of *s*:—

1856, Oct. 30	*s* = 12·3	1857, March 1	*s* = 13·2
Nov. 8	13·5	18	12·1
Dec. 2	13·5	20	11·9
1857, Jan. 20	not visible.	23	12·7
Feb. 21	not visible.	24	13·2

"These numbers, being deduced from comparison with stars of nearly the same brightness, might be regarded as exact within the limits of the exactitude with which the relative brightness of the comparison stars has been estimated by me. But here arises a new difficulty; for there are strong evidences that those comparison stars are equally subject to changes of light.

"The first of these stars, that exhibited strong indications of a variable light, was 75; but it was not until the last day's observations that I could satisfy myself entirely on this point. On the evening of March 1 it was so feeble that it could only be recognised by glimpses, and was not to be seen steadily; March 18, it offered almost the same appearance, so that I noted that it was certainly considerably inferior to 57. On the contrary, two days later, March 20, it was brighter than 57, but less bright than 51. From March 20 to 23 it appears to have yet a little increased in brightness; for on the last day I noted that it was now nearer to 51 than to 57. On the following night, March 24, it was again less bright than 57. From these observations, I think, there cannot remain a doubt about the variability of light in this star, unless the two chief comparison stars 51 and 57 were not themselves subject to changes of light; but even in that case the great difficulty I had to see 75 in the nights of March 1 and 18, while

Digitized by Google

the other stars remained easily visible, would be a sufficient proof of its variability. From these observations the greatest changes of light of star 75 would, however, hardly exceed one magnitude; for it never was so feeble as to disappear entirely in our refractor (or less than 13·5), and never has been seen brighter than 12·5.

"Either 51 or 88 is equally subject to change of light. During the whole season 88 had taken the lead in the order of brightness of the indicated 5 stars of Herschel's Catalogue; but in the last night, March 24, there was no doubt 51 was far the brightest of them. I am not quite sure to which of those two stars to attribute the aforesaid change; but from the most noticed change of the relation of 51 to 57, I am inclined to think that 88 is the variable star.

"Of Herschel's star 78 I could not see the least trace, neither in the beautiful night of Oct. 30, nor in any of the subsequent nights, until March 20. This last date I thought I could see it by glimpses; but was not quite sure on this point. On the evening of March 24 it was distinctly visible, so that I was enabled to determine its position by estimation. Hence it appears that in the last period of my observations this star was on the increase.

"We have, therefore, amongst the 6 observed stars in the *Regio Huygheniana*, on a space of 3 to 4 square minutes, at least 4 variable stars; but I think the number of variable stars in the same region will yet be considerably increased by further observations. The sixth star of the trapezium, for instance, bears strong indications of variability. On former occasions I agreed perfectly with Mr. Lassell's remark, that this star was fully of equal brightness with the fifth star; but this year it appeared to me constantly inferior. Perhaps this variability will explain the circumstance, that this sixth star, even after its discovery by Herschel, could never be seen by my father in the Dorpat refractor, while the fifth star was regularly observed. Probably, also, two or three stars seen and measured by Mr. Lamont in 1837, will be found of variable light; for I do not think that stars, distinctly seen by the Munich refractor, should be entirely out of the reach of visibility at Pulkova, if they have not undergone considerable changes of brightness. Finally, perhaps some of the stars indicated, but rather suspected than observed, by De Vico, Bond, and others, in the immediate vicinity of the trapezium, might equally be found of variable light.*

"The existence of so many variable stars on such a small space in the central part of the most curious nebula in the heavens, must of course induce us to suppose these phenomena intimately connected with the mysterious nature of that body. But perhaps our knowledge of variable stars generally, and of minute stars especially, may not be considered at present sufficiently extended to admit conclusions of almost mathematical strength. Therefore,

* A letter from the Rev. W. R. Dawes on the detection of duplicity of a star in this nebula, published in the *Monthly Notices*, vol. viii. page 31, will now be read with increased interest and signification.—[EDITOR.]

Digitized by Google

we must proceed by steps. One of the first questions that presents itself must be, Is the space of frequent variable stars limited by the Huyghenian region, or does it extend over the whole nebula? To answer this question peremptorily, we do not as yet possess sufficient data. The relative magnitudes indicated in Mr. Lassell's excellent catalogue, compared with those observed by Liapounov in the years immediately preceding the period of Lassell's observations, offer throughout an almost perfect agreement; so that we must conclude that in the short interval of their respective observations, no material change has happened in the *mean* brightness of any of the stars that are common to both observers. The agreement is somewhat less complete if we compare Sir J. Herschel's Catalogue with those of Lassell and Liapounov; but the differences in the indicated magnitudes, if reduced to the same scale, are not so great as to exceed the limits of admissible errors of estimation. In one instance, however, I am inclined to suppose a considerable variability of light. The star, No. 20, of Lassell's Catalogue, seen likewise by M. Liapounov, is the only star observed by those two astronomers, that does not occur in Herschel's list ($\Delta\alpha = +\ 320''{\cdot}1$; $\Delta\delta = -\ 184''{\cdot}0$). It is hardly admissible to suppose that, with the extraordinary care expended by Sir J. Herschel in the preparation of his catalogue, a star should have been overlooked by him that was bright enough to be distinctly seen in the Kazan refractor; the more so, as this star is situated in a very remarkable part of the nebula, in the *Regio Subnebulosa*, near the vertex of the angle formed by the sudden turn to the south of the *Proboscis Major*. The supposed variability of light in this star is supported by the fact that during the last winter this star belonged to the most difficult objects discernible by the Pulkova refractor, and certainly was inferior in light to many other stars that had been out of the reach of the Kazan refractor.

"On the contrary, the comparison of Bond's Catalogue would have led to many extraordinary conclusions; but I do not think those conclusions of any weight; for it appears that the said catalogue is crowded with errors, and worked without any system. Apparently, the author has expended more care on the graphical representation of the nebula than on the construction of the catalogue.

"Admitting that the observed rapid changes of light of those minute stars are connected with the nature of the nebula, it might be presumed we should equally be able to observe changes in the appearances of the nebula, and the distribution of the nebulous matter. But observations of this kind are subject to so many illusions that we cannot be cautious enough with regard to the conclusions to be derived from them. I do not think the common way followed by astronomers in the researches of this kind, viz. to compare with one another graphical representations made at different epochs by different observers, will ever lead us to results that might be regarded as above all doubt. The optical

Digitized by Google

power of the telescope, the transparency of the atmosphere at different stations, the peculiarities of the eye of the observer, the degree of skill and experience in graphical representations of this kind, together with the influence of the imagination of the observer, form obstacles that it will ever remain difficult to remove if we proceed in this way. Perhaps, by continuing the same system during centuries, we might detect, if they exist, changes of a progressive nature; but we should never be able to ascertain changes that happen in short intervals. Now the observed rapid changes of light in the stars, must of course lead us to expect similar rapid, perhaps periodical, changes or fluctuations in the appearance of the nebulous matter. It is, therefore, to similar rapid changes that we have particularly to direct our attention; and we shall be much more able to ascertain their existence by comparative observations on the brightness and forms of some prominent portions of the nebula, than by general representations of it. We must as much as possible concentrate the observations on singular parts, and not extend them over the whole body at once. It is in this way that I have tried to proceed during the last winter, and I consider myself justified in saying that on different points I have been strongly impressed with considerable changes that have happened during the comparatively short period of my observations. Nevertheless, being fully aware to how many illusions similar observations are subject, I do not venture to regard these observations as positive facts, until they shall have found further corroboration, especially by observers placed in more favourable climates and provided with sufficient optical means for that purpose. With this view I beg leave to recommend to their attention the following parts of the nebula:

"1. The bay, that extends from the *Sinus Gentilii*, in the direction to the trapezium. This bay has been delineated for the first time by Dr. Lamont, and has never been seen by Sir J. Herschel (*Cape Observations*, p. 32 (69)). Last autumn this bay appeared to me quite as dark as the *Sinus Gentilii;* but in the month of March it was filled with nebulosity, very little inferior in brightness to the surrounding portions of the *Regio Huygheniana.*

"2. The nebulous bridge, that apparently crosses the *Sinus Magnus*, with a point of concentrated light in the middle. Herschel has represented this bridge; but perhaps not strongly enough, and certainly not far enough extended, and without the mentioned concentrated light. Lamont has only very feeble traces of it; Bond has not seen it at all; finally, Liapounov has given it in the shape of a promontory, with a strong concentration of light on its extremity. I have seen it during this winter, sometimes more resembling to Herschel's delineation; on other occasions, with the strong concentrated light, like Liapounov; but always extending considerably farther to, and nearly, if not entirely, approaching, the southern boundary of the *Sinus Magnus.*

"3. The nebulosity near and round the star 75 of Herschel's

Digitized by Google

Catalogue. This nebulosity appeared to me subject to considerable changes of brightness.

"4. A sort of narrow channel, that connects in apparently a straight line the black space round the stars 76, 80, and 84, of Herschel's Catalogue, with the northern border of the *Sinus Magnus*, where it has its mouth near to the outer extremity of the before-mentioned bridge. This channel, that never has been represented by any other observer, was distinctly seen on March 24; but I could not entirely satisfy myself if it was interrupted or not in the neighbourhood of the star 87. On former occasions, when I had very carefully reviewed this same portion of the nebula, I had never seen a trace of the channel. The space round the three mentioned stars appeared to me sometimes quite dark, sometimes filled with nebulosity; but even when this nebulosity was the strongest, it was regularly defined, and appeared throughout of an uniform light, without any gradation similar to that represented by Herschel.

"My journal contains yet some more indications of suspected changes, but in no other case, besides the four mentioned, do I estimate the suspicion strong enough to invite other astronomers to direct their particular attention to them. However, I may add, that the general impression I have derived from the observations of this year has been that the central part of the nebula of *Orion* is in a state of continual change with regard to the brightness in different parts of it. Even with the best definition of images, its appearances were to me on no evening entirely agreeing with those on the next or any other night. Perhaps it will save trouble to astronomers, not provided with great telescopes, if I remark, that for the greater part such changes in the gradation of light can only be seen with very high optical means. In my opinion refractors of less than 10 inches aperture, if not supported by an extraordinary state of the atmosphere, would hardly prove themselves equal to the task.

"1 *May*, 1857."

Letter from Mr. Bond, Director of the Observatory, Cambridge, U. S., to the Secretary.

"It affords me pleasure to communicate the following results of our experiments instituted at this Observatory for the purpose of delineating the positions of a group of stars by the aid of photography.

"On the evening of the 27th of April the actinic apparatus was affixed to the 23-feet equatoreal. The groups of stars to be experimented upon consisted of *Mizar*, second magnitude, its companion of the fourth magnitude, and *Alcor*, of the fifth magnitude. These were taken simultaneously by the collodion

Digitized by Google

process. The images were distinct, and, although covering some seconds of arc, were so perfectly symmetrical that they were capable of very nice bisection. On the following day they were measured in distance, by Mr. Alvan Clark, with a reading microscope, as follows:—

Mizar to *Alcor*.	*Mizar* to companion.	Angle at *Mizar* between *Alcor* and companion.
r d	r d	
14 304·5	0 109·2	
303·6	110·5	
303·5	110·5	
303·0	110·3	° ′ 75 55
303·6	110·3	76 05
14 303·6	110·2	76 00

One revolution of the micrometer-screw is subdivided into 360 parts.

"From these measurements of the photographic images we obtain

"*Mizar* to *Alcor* = 14ʳ·8433; *Mizar* to companion = 0ʳ·3061; distance of companion = 0·02062 of distance of *Alcor*.

"To reduce this to seconds of arc we have from the Greenwich catalogue:—

Diff. Right Ascension *Mizar* and *Alcor* = 1 m 19·67 s

,, Declination ,, ,, = 3 ′ 40·3 ″

which gives the distance of *Alcor* from *Mizar* = 707″·8 in an arc of a great circle, and the distance of the companion from *Mizar* 707″·8 × 0·02062 = 14″·6.

"The computed angle of position of *Mizar* and *Alcor* is 72°·0. Adding the difference of the angles of position of the companion and *Alcor*, we obtain for the angle of position of the former 72°·0 + 76°·0 = 148°·0.

"Struve's observations, 'Positiones Mediæ,' Introd. p. 215, are as follows,—

	Distance.	Angle of Position.
	″	°
1830·63	14·37	147·6
1840·77	14·35	147·7
1847·65	14·25	148·2
Mean	14·33	147·8

"The observations of Bradley and Herschel in the last century prove that there is very little, if any, relative motion of the two stars. Taking Struve's places as correct for the present epoch, we have the following comparison between the photographic angles and those derived from direct measurement.

Digitized by Google

"Angle of position and distance of *Mizar* (*ζ Ursæ Majoris*) and its companion:—

	Photographic.	Struve.
Angle of Position	= 148°·0	147°·8
Distance	= 14″·60	14″·33

"Whether this close agreement is to be attributed partly to accident must be determined from further experiments, but it may be well to state that from the manner in which they have been obtained there could have been no bias in the measurements favourable to the photographic results.

"Some six years ago we published in the *Boston Traveller* an account of our having obtained daguerreotype impressions of the stars *Vega* and *Castor* by the aid of the great refractor, but at that time it was found impossible to extend the process to stars of lesser magnitude. This was attributed to the want of sufficient susceptibility in the daguerreotype plates, and to deficiency of power and regularity in the machinery designed for giving to the telescope uniform sidereal motion. These deficiencies have been recently supplied, first, by the construction of a driving-clock on the principle of the 'spring-governor,' in which the rotary motion of the fly-wheel is regulated by an oscillating pendulum, which has been found, from several years' practical application, to be the most perfect regulator of rotary motion yet devised. A machine of this description has been adapted to the great telescope by those excellent mechanicians, Messrs. George Clark and Alvan Clark, jun., of East Cambridge, assisted by their father, Mr. Alvan Clark, sen.

"This point having been satisfactorily accomplished, we obtained the assistance of Messrs. Whipple and Black, whose skill as daguerreotypists is unsurpassed, and whom we knew to be deeply interested in the success of the experiment: it is to those gentlemen that we are principally indebted for whatever of success has crowned our efforts in the perfect delineation of stars of the lesser magnitudes.

"I should mention that a zero for angle of position is obtained with neatness and precision by allowing the star, after the first impression has been taken, to move forward by its diurnal motion, and then renewing the image on the same plate. The line joining these two images will represent the direction of the circle of declination. We have several series of *Mizar* and *Arcturus* taken in this way.

"P.S. — Since the above was written we have measured the distance between *Mizar* and its companion from plates taken on four different nights — the angles are all but identical — showing that the first measures were not the result of accident.

Digitized by Google

At the close of the meeting the Astronomer Royal made an oral statement respecting certain ancient eclipses which have recently engaged his attention. A few years ago he communicated to the Royal Society a paper on the eclipses of Thales and Agathocles which was published in the *Philosophical Transactions* of that body for the year 1853. The circumstances connected with both these eclipses are known to every reader of ancient history. The eclipse of Thales happened during the occurrence of a battle between the Medes and Lydians; and according to Herodotus, the combatants on both sides were so terrified by the spectacle that an immediate cessation of hostilities ensued, and peace was concluded between the two nations. The account of the eclipse of Agathocles which has been given by the ancient writers is also associated with a very remarkable incident. Agathocles having been closely blockaded in the harbour of Syracuse by a Carthaginian fleet, took advantage of a temporary relaxation of the blockade occasioned by the enemy going in pursuit of a relieving fleet of ships laden with provisions, and quitting the harbour of Syracuse he landed on the opposite coast of Africa, and laid waste the Carthaginian territories. It is stated that the voyage to the African coast occupied six days, and that an eclipse (which from the description was manifestly total) occurred on the second day.

The late Mr. Baily, in a paper published in the *Philosophical Transactions* for 1810, had come to the conclusion that the eclipse of Thales must have occurred in the year 610 B.C., but he found it impossible by means of the same elements of the moon's orbit to satisfy the conditions of the eclipse of Agathocles.

The object of the Astronomer Royal in the paper above mentioned was, by means of the improved state of lunar astronomy, to fix the precise time of the occurrence of the eclipse of Thales using for this purpose the eclipse of Agathocles as a critical eclipse and supposing the place of the moon's node to be liable to error. The conclusion at which he arrived was that an eclipse which occurred in the year 584 B.C., is the one referred to by Herodotus, and not the eclipse of 610 B.C., as Baily supposed.*

The subsequent researches of Mr. Adams on the secular acceleration of the moon's mean motion, and the publication of the Solar Tables of MM. Hansen and Olufsen, having led Mr. Airy to suspect that the groundwork of his previous calculation was imperfect, he proceeded to investigate the subject anew. On this occasion he employed in his researches (in combination with the eclipses of Thales and Agathocles) the eclipse of Larissa, to which his attention had been invited, first by Mr. Hind, and afterwards by Mr. J. Bosanquet. This eclipse is mentioned by Xenophon in the *Anabasis*, as having led to the capture by the Persians of a Median city which he calls Larissa. In the retreat of the Greeks on the eastern side of the Tigris, not long after the seizure of their

* Mr. Airy here stated that a similar conclusion had been derived by Mr. Hind from good elements.

Digitized by Google

generals, they crossed the river Zapates, and also a ravine or steep watercourse, and then came to the Tigris. At this place there stood, according to Xenophon, "a large deserted city called Larissa, formerly inhabited by the Medes; its wall was 25 feet thick, 100 feet high; its circumference 2 parasangs; it was built of burnt bricks, placed upon an understructure of stone 20 feet high. When the Persians obtained the empire [of the east] from the Medes, the king of the Persians besieged the city, but could not in any way take it, but a cloud covered the sun and caused it to disappear completely, till [*i. e.* to such a degree that] the inhabitants withdrew, and thus the city was taken.* Close to this city was a pyramid of stone, 1 plethrum in breadth, 2 plethra in height. Thence the Greeks proceeded 6 parasangs to a great deserted castle, by a city called Mespila, formerly inhabited by the Medes; the substructure of its wall was of squared stone abounding in shells; the king of the Persians besieged it, but could not take it; Zeus, however, terrified the inhabitants with thunderbolts, and so the city was taken."

The minute description here given by Xenophon has enabled Layard, Jones, and others, to identify Larissa with the modern Nimrûd, and Mespila with the Mosul of the present day. It is plain that the phenomenon to which the Greek author refers as having led to the capture of Larissa, was no other than a total eclipse of the sun.

The Astronomer Royal accordingly examined approximately all the eclipses which occurred within an interval of forty years, including the given period, and having selected two he computed them accurately, but found them inapplicable. He then tried another (556, May 19, B.C.) which he had previously passed over because he doubted its totality, and had the great satisfaction of finding that the eclipse, though giving a small shadow, was total, and that it passed so near to Nimrûd that there could not be a doubt of the eclipse sought.

Mr. Airy then proceeded to explain the method of investigation which he employed in the discussion of these ancient eclipses. A brief account of this method is given in an abstract of his paper on the subject which will be found at page 243. The conclusion to which he has been conducted by his researches, is that Professor Hansen's Solar and Lunar Tables very well represent the phenomena of the three eclipses of Agathocles (309, Aug. 14, B.C.), Larissa (556, May 19, B.C.), and Thales (584, May 28, B.C.), as far as we can interpret the historical account of those eclipses.

It may be stated that the remarks of the Astronomer Royal were illustrated by topographical sketches of the localities of the

* Ἡλίου δὲ νυφίλη παρακαλύψασα ἠφάνισε, μίχρι ἑξήκοντα οἱ ἄνθρωποι, καὶ οὕτως ἑάλω.—*Anab.* lib. iii. cap. iv. A suspicion is thrown out in some editions of the *Anabasis*, that this may refer to an eclipse of the sun, but the passage seems to have been overlooked by Kepler (*Astronomiæ Pars Optica*), nor has Riccioli included it in the list of eclipses which he quotes from the ancient writers, in his elaborate work the *Almagistum Novum*.—R. G.

Digitized by Google

different eclipses, by which the audience were enabled to obtain a clear view of the historical circumstances connected with the subject.

On the Variable Star B. A. C. 3345 (R *Leonis*).

By Joseph Baxendell, Esq.

This star, to which the Astronomer Royal has drawn attention in the last number of the *Monthly Notices*, was discovered to be variable by M. Koch in 1782; but from the little attention which it afterwards received, it was long supposed to be a very slow-changing variable, and to have a period of many years' duration. Later observations have, however, shown that its period does not exceed 10½ months. It is the star named R *Leonis* by Professor Argelander, and is No. 25 of Mr. Pogson's very useful "Catalogue of Fifty-three Variable Stars" in the 15th volume of the *Radcliffe Observations*, where it is stated to have a period of 313 days, and to vary from the 5th magnitude at maximum to the 10th at minimum. Mr. Pogson remarks that "the maximum magnitude of this star is by no means regular, but the light at such times is vividly red," and that "the period is also rather irregular."

Since the beginning of the year 1840 I have occasionally watched this star, and my observations have afforded the following times of maxima:—

1840, May 23.	1853, March 16.
1848, December 12.	1854, January 27.
1849, October 15.	1854, December 6.
1852, May 7.	1855, October 13.

From these data I have obtained for the mean period, 312·23 days; and for epoch, 1851, July 3·58. Calculated from these elements the maximum for 1857 ought to occur on June 27. In the March number of the *Monthly Notices*, p. 149, Professor Argelander gives June 21 as the probable time of this maximum.

A projection of all my observations on the basis of a mean period of 312·23 days shows that R *Leonis* belongs to the list of variables, which increase in brightness more rapidly than they diminish,—the interval from minimum to maximum being about 146 days, and from maximum to minimum, 166 days. The mean maximum magnitude is 6·2, and the mean minimum, 10·5; the extremes in the former case being 5·9 and 6·5, and in the latter 10·0 and 11·2. It appears, therefore, that the irregularities in the magnitude at minimum are much greater than those at maximum.

The red colour noticed by Mr. Criswick and Mr. Dunkin is considered by Mr. Pogson to be most decided at the time of maximum brightness (*Monthly Notices* for December, 1856, p. 24). In my observations the colour, when noticed, has always been described as "deep reddish-yellow," or "yellowish red."

Manchester, May 19, 1857.

Digitized by Google

On the Effect of Local Attraction in modifying the apparent form of the Earth, and some Remarks on the Real Existence of Diversity of Form, independent of their Effect. By Lieut. J. F. Tennant, Bengal Engineers, F.R.A.S., First Assistant G. T. Survey of India.

"In a paper I sent some time ago to the Society, I entered on an examination of the practical value of the results deduced by Mr. Pratt from his 'Estimate of Himmaleyan Attraction,' and showed that he failed in satisfying the geodesical data of the great longitudinal series.

"I have since received a letter from Mr. Pratt pointing out that I have extended his result beyond the limit he intended it to have. The ellipse given there would appear to be only a section of the supposed protuberant surface on that arc. It is useless for geodesical purposes, and I think there is no evidence that it is a real form at all.

"If, moreover, we suppose it to start at the southern extremity, cutting the mean ellipse, it will lie entirely within the mean surface, and can in any case only cut that surface at one point. The estimated projection of the surface at its centre above its chord is not then a measure of its difference from the general surface, as the chords of the two surfaces will be totally different. An ellipse representing a protuberance would generally require to have the extremity of its major axis out of the equatorial point, and this would satisfy three arcs. Hence the error into which I fell in interpreting Mr. Pratt's ellipse.

"The letter to which I have referred has again drawn my attention to the paper in the *Philosophical Transactions;* and in endeavouring to account for results so unexpectedly large, I have been led to the conclusion, that with Mr. Pratt's Hypothetical Attractions a further and very sensible correction to the measured lengths would be needed, and to some result on the modification of the mean figure, by attracting masses which will, I trust, be considered interesting.

"It is sufficiently shown in Mr. Pratt's paper that the order of error arising from neglecting the consideration that the visible side is projected on an erroneous plane is rejectaneous. Indeed it will appear evident that the neglect of $\frac{dR}{d\theta}$ in the expression

$$\frac{ds}{d\theta} = \sqrt{R^2 + \left(\frac{dR}{d\theta}\right)^2}$$

will be rejectaneous (in all cases where the attraction is not far more certainly known than from Mr. Pratt's formula,) in the following investigation.

"I purpose therefore assuming that the attraction of the Himmaleh may be sufficiently represented by a force varying inversely

Digitized by Google

as the chord of an arc drawn from the station perpendicular to the equivalent attracting prism (art. 50 of Mr. Pratt's paper) and, further, that it acts in the direction of the chord, which assumptions, while they have no sensible influence in modifying the attractions within the limits of the two arcs, are essential to the extension of the law farther from the prism.

"If, then, θ be the arc distance of any point from the prism, the deflection of the plumb-line would be

$$\frac{7235'' \cos \frac{1}{2}\theta}{2\,R \sin \frac{1}{2}\theta} = \varphi$$

or,

$$\varphi = \frac{7235''}{2\,R} \cdot \cot \tfrac{1}{2}\theta.$$

"Also $ds = R\,d\theta$.

"Therefore the extremity of ds would be elevated by

$$-\tan \varphi\, ds = -\frac{7235 \tan 1''}{2\,R} \cdot R \cot \tfrac{1}{2}\theta \cdot d\theta$$

above its true place were the attraction eliminated.

"Hence,

$$d \cdot \partial R = -7235 \tan 1'' \cdot \cot \tfrac{1}{2}\theta \cdot \frac{d\theta}{2}$$

$$\partial R = 7235 \tan 1'' \int \cot \tfrac{1}{2}\theta \cdot d\theta$$

or if ∂R be in feet, R being miles,

$$\partial R = -\frac{38200800}{M} \tan 1'' \{\log \sin \tfrac{1}{2}\theta + C\}$$

"If ∂R be supposed to vanish when $\theta = \frac{\pi}{2}$ we shall have

$$\partial R = \frac{38200800}{M} \tan 1'' \{\log \sin 45^\circ - \log \sin \tfrac{1}{2}\theta\}$$

$$= \log^{-1} 2{\cdot}629863_0 \{9{\cdot}8494850 - \log \sin \tfrac{1}{2}\theta\}$$

"Now, taking R = 3960 miles, we should have at

Damergida	$\theta =$	13	55	$\therefore \frac{1}{2}\theta =$	6	57	30
Kalianpur	$\theta =$	8	10	$\therefore \frac{1}{2}\theta =$	4	5	0
Kaliana	$\theta =$	3	13	$\therefore \frac{1}{2}\theta =$	1	36	30

"Whence the radius vector would have been increased at

Damergida	by ∂R =	326·7 feet
Kalianpur	by ∂R =	425·4 ,,
Kaliana	by ∂R =	597·6 ,,

} A

"Also, since

$$-\frac{38200800}{M} \tan 1'' \int_{\pi}^{\frac{\pi}{2}} \cot \tfrac{1}{2}\theta \frac{d\theta}{2} = 64{\cdot}2 \text{ feet};$$

Digitized by Google

this would be the increment of the radius vector from the antipodes of the centre of the prism to the great circle, whose pole is its centre, which is the origin of the quantities A.

"If these amounts A be the true increments of the radius, then the southern arc would require a correction of $-35{\cdot}3$ feet, and the northern of $-53{\cdot}9$ feet. Small as these are in comparison with the corrections necessary to make Mr. Pratt's attractions consistent with the general figure, they are far larger than those he has found in his paper.

"If we knew the true law of any attraction, we could assign φ as a function of λ and L, the geocentric latitude and longitude, and R_1 and s being measured to and on the apparent surface, we should have

$$d \cdot R_1 = \frac{d R}{d \lambda} \cdot d\lambda + \tan \varphi \sqrt{\left(\frac{d s}{d \lambda}\right)^2 \cdot d\lambda^2 + \left(\frac{d s}{d L}\right)^2 \cdot d L^2}$$

"One result of this perturbation of the radius vector is, that every mass whose tendency is to raise the horizon towards itself, will cause a sensible protuberance of surface, and each which depresses the horizon will cause a depression. This disturbance of the surface is independent of its *real* form. The mere superposition of the mass of the Himmaleh, as estimated by Mr. Pratt without any alteration in the rest of the surface, would cause the surface at Kaliana to appear depressed by nearly 600 feet.

"It is evident that we have here a form of protuberance which, while entirely the result of attraction, is insensible to levelling operations entirely. It therefore differs entirely from the physical changes which are appealed to for the probability of real changes. Every mountain mass, by virtue of its attraction, causes a protuberance which is removed by the elimination of the effects of the attraction; so does every mass internally of greater density than the average of the stratum, but all these changes are dependent on the local disturbances of the plumb-line, and are not included in the tacit definition given by Mr. Pratt. The only change reconcilable with his process of eliminating the effect of irregular disturbance is a form so limited as that it shall have the power of keeping the vertical always normal to its surface. The only form, I believe, which possesses this property is an ellipsoidal shell concentric with the general form, and which would, therefore, merge in it. A protuberance of 157 feet at the centre of an arc, $11\frac{1}{2}$ degrees in length, and merging in the figure at both ends, would not have this effect any more than a flat rounded hill.

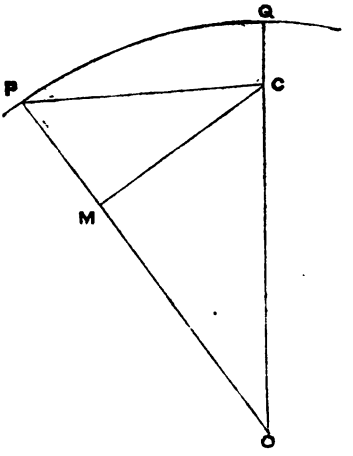
"If I am correct in this belief, it is a necessary corollary that every apparent local protuberance will be an effect of the neglect in part, or *in toto*, of the irregular deflections of the plumb-line, and that did our imperfect knowledge permit us entirely to eliminate this source of error, we should have a figure of equilibrium as the result independent of any speculations as to the processes by which the present distribution of matter in the earth has been attained.

Digitized by Google

"I will conclude with an examination of the mass which, acting in the centre of an arc, would produce an elevation similar to that which is the asserted result of Mr. Pratt's investigations.

"I shall in this consider the surface as sufficiently satisfying the equation $ds = R\,d\theta$, where R is constant, and also that the mass causing deflection can be considered as concentrated in a point. The former hypothesis can cause no sensible error, and the latter will answer my purpose, which is (a rigorous investigation being out of the question) merely to show how small a mass will suffice to produce the result.

"In the accompanying figure let P Q represent the curbed surface; O its centre; O P = O Q = R the radius. Let C be the centre of the attracting mass, and C Q = r. Let the angle P O C = θ, the deflection at P = ϕ, and the deflecting mass which I will call the mass C = earth's mass $\times \frac{1}{m}$.



"The attraction of C on P : attraction of the earth on P :: O P^2 : m P C^2.

"Consequently the resolved portion in the direction of the tangent at P = attraction of earth on

$$P \cdot \frac{O\,P^2}{m\,P\,C^2} \times \frac{C\,M}{C\,P}$$

C M being perpendicular to P O; and the portion parallel to P O is rejectaneous compared with the earth's attraction.

"Now,

$$C\,M = C\,O \sin\theta = (R-r)\sin\theta$$

and

$$P\,C^2 = (R-r)^2 + R^2 - 2R\,(R-r)\cos\theta$$
$$= r^2 + 2R\,(R-r)\sin^2\tfrac{1}{2}\theta$$

therefore

$$\tan\phi = \frac{R^2\,(R-r)\sin\theta}{m\left\{r^2+2R\,(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}} = \frac{2R^2\,(R-r)\sin\tfrac{1}{2}\theta\cos\tfrac{1}{2}\theta}{m\left\{r^2+2R\,(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}}$$

"Hence,

$$d\,\delta R_2 - R\,d\theta\tan\phi = -\frac{2R^3\,(R-r)\sin\tfrac{1}{2}\theta\cos\tfrac{1}{2}\theta}{m\left\{r^2+2R\,(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}}$$

"Integrating, we find the value of

$$\delta R \text{ at } Q = \Delta R = \frac{2R^2}{m}\int_0^{\theta} \frac{2R\,(R-r)\sin\tfrac{1}{2}\theta\cos\tfrac{1}{2}\theta\,.\,d\theta}{\left\{r^2+2R\,(R-r)\sin^2\frac{1}{2}\theta\right\}^{\frac{3}{2}}}$$
$$= \frac{R^2}{m}\left\{\frac{1}{r} - \frac{1}{\sqrt{2R\,(R-r)\sin^2\frac{1}{2}\theta + r^2}}\right\}$$

Digitized by Google

or if ΔR be feet,

$$\Delta R = \frac{5280\, R^2}{m}\left\{\frac{1}{r} - \frac{1}{\sqrt{2R(R-r)\sin^2\frac{1}{2}\theta + r^2}}\right\}$$

"Let

$$r = 52{\cdot}8 \text{ feet} = 0{\cdot}01 \text{ mile}$$
$$R = 3960 \text{ miles}$$
$$\Delta R = 157 \text{ feet.}$$

2θ = difference of latitudes of the extremities

$$= 11^\circ\, 27'\, 32'' \text{ or } \tfrac{1}{2}\theta = 2^\circ\, 51'\, 53''$$

"Then

$$\Delta R = \frac{5280\, R^2}{m}\left\{100 - 0{\cdot}0035728\right\}$$
$$= \frac{\log^{-1} 12{\cdot}9180093}{m} = 157$$

therefore

$$m = \frac{\log^{-1} 12{\cdot}9180093}{157}$$
$$= \log^{-1} 10{\cdot}7221096$$

"If we suppose this mass half the mean density of the earth, the sphere containing the necessary volume would be 1·351 miles in radius.

"Such a protuberance then might, in the case of the Indian arc, easily be produced by the elevated masses of Central India, whose greater volume would be counteracted by their diffusion of a large space.

"The attraction, then, of this mass on a station situated like Kalianpur, where $\theta = 20'\, 9''$ would be

$$\varphi = \tan^{-1}\frac{R^2(R-r)\sin 20'\, 9''}{m\left\{r^2 + 2R(R-r)\sin^2 10'\, 4''{\cdot}5\right\}^{\frac{3}{2}}} = 6''{\cdot}67$$

"This, in conjunction with the correction to the measured arc, would satisfy (even with Mr. Pratt's attractions) very closely the southern arc (Damergida to Kalianpur), considered as measured on the average spheroid. That, however, is accidental. Mr. Pratt's form does not, like this, meet the general ellipse in the ends of the arc.

"Since, then, we can account for apparent deviations of the surface of the earth from the mean form by, as I think I have shown, the effects of the attraction of small masses of matter; and we have, and can have, no evidence of the real existence of deviations which are independent of this source and real; it appears to me not consistent with the principles of induction to assign such as we may imagine we find to the latter cause.

"I have shown in my former paper that the ellipse given by Mr. Pratt for the Indian meridian is useless for geodesical purposes. I have now, I think, shown reason to believe that there is

Digitized by Google

no evidence which will warrant our considering that any real departure from the mean form exists.

"The following conclusion is not without its importance: It is impossible to place any dependence on a figure deduced from neighbouring arcs, even within their own limits, as considerable deviations may be caused by the attraction of small masses favourably situated; and the only figure of any geodesical or astronomical importance is that determined as usual from the consideration of a considerable number of arcs situated in various circumstances as regards sources of probable local disturbances."

Extract of a Letter from M. Schwabe to Mr. Carrington.

(*Translated freely.*)

"In the address of the President, contained in your *Monthly Notices*, the question is inadvertently asked, of what led me originally to undertake observations of the sun. It was in consequence of a representation of my old and valued friend Harding of Göttingen, who wrote to me that there was a great want of physical observations of the sun, that the subject presented an almost unworked field, and that labour therein might be rewarded by the discovery of a planet interior to *Mercury*. The communications of Harding and of a friend in Berlin led me also to inquire into the rotation of the sun, in which I found some difficulty from the instability of the spots. Nevertheless, I convinced myself that the opinion of Schroeter, that the spots had an independent motion, was unfounded, and that the apparent movement was attributable rather to the enlarging of one side and the filling in of the other side of a nuclear spot, whereby the estimated centre was shifted. My enumerations, however, early led me to notice a tolerably regular increase and decrease in the number of the spots, so that I may compare myself to Saul, who went out to seek his father's asses, and found a kingdom."

Report of the Syndicate appointed to visit the Observatory of Cambridge (*May* 30, 1857).

We extract the following passages from this Report:—

"The transit observations in the year 1856 amounted to 1865, and the circle observations to 1121.

"The total number of comparisons in R.A. (with the Northumberland equatoreal), is 695, and of those in N.P.D. 585.

Digitized by Google

"The number of occultations of fixed stars by the Moon observed in 1856 was 14.

"On May 30 Professor Challis informed Dr. Peters, the Editor of the *Astronomische Nachrichten*, that it was his intention to observe a limited number of the Minor Planets, and that he had selected the eight following: *Flora*, *Metis*, *Victoria*, *Themis*, *Proserpina*, *Bellona*, *Urania*, and *Leucothea*. A similar selection had previously been made at the Observatories of Washington and Altona, and several other Observatories have since adopted the same plan. It is expected that by this distribution of the work of observing the large number of these bodies now known, needless observations will be avoided, and each body will receive a due amount of attention.

"In July and August of last year repeated attempts were made by Professor Challis and Mr. Breen with the Northumberland telescope to find the planet *Leucothea* at the time of its opposition. The search proved ineffectual in consequence, most probably, of the invisibility of the planet from its small magnitude and low altitude. The efforts of the Berlin astronomers were alike unsuccessful.

"The observations of zodiacal stars and of planets on the meridian have suffered some interruption during the last half-year, owing principally to changes that have taken place in the personal establishment. Keeping still in view the formation of a star-catalogue, Professor Challis proposes to select for especial observation in future the stars that have been employed for comparison in equatoreal observations, for the purpose of preparing for the final reduction of the observations of planets and comets made in past years with the Northumberland telescope. Many of these stars are included in the list of zodiacal stars.

"The equatoreal observations of the minor planets were not restricted to the eight above mentioned, until the beginning of the present year. The others are still observed on the meridian near the times of opposition whenever they can be well seen, and in case ephemerides are provided either in the *Berliner Jahrbuch*, or by the superintendent of the *Nautical Almanac*. The planet *Neptune* is observed as in former years.

"From the commencement of the year to May 22 the number of transit-observations amounts to 430, and the number of circle observations to 287. In these are included 63 transits and 72 circle observations of the following objects: The Sun, *Hebe*, *Parthenope*, *Proserpina*, *Iris* and *Fallas*.

"The Northumberland equatoreal has been employed in the same interval upon the planets *Proserpina*, *Themis*, *Polyhymnia*, *Urania*, *Bellona*, and a new planet discovered by Mr. Pogson, at Oxford, on April 15, and upon two comets, one discovered on February 22 by Professor D'Arrest, and the other on March 18 by Dr. Bruhns. The latter comet has been identified with that discovered by Brorsen in February of 1846, which was diligently searched for by Mr. Breen on its expected return in 1851. It

Digitized by Google

now appears that the elements of the orbit computed from the observations of 1846, which extended over only two months, were considerably in error, and that the comet escaped detection in 1851, probably from the inaccuracy of the sweeping ephemeris.

"Occultations by the moon have been attended to as usual. The occultation of *Jupiter* and his satellites on January 2 presented peculiar phenomena, which Professor Challis observed with the Northumberland telescope under very favourable circumstances. The reduced times of observation, the physical appearances of the planet and satellites, and the jovicentric distances of the satellites calculated from the observed times, have been communicated to the Royal Astronomical Society.

"The equatoreal mounting of the Dollond 46-inch telescope, spoken of in the last Annual Report, has been completed by Mr. Simms, and appears to be satisfactorily executed. The apparatus was received so recently that there has not been time to place it on an equatoreal stand, or to form an opinion of the quality of the new object-glass."

On the Eclipse of Agathocles, the Eclipse at Larissa, and the Eclipse of Thales. By G. B. Airy, Esq., Astronomer Royal.

The author, adverting to his paper on the eclipses of Agathocles and Thales, in the *Philosophical Transactions*, 1853, in which the eclipse of Agathocles was used as the cardinal point of reference whereby to correct the motion of the moon's node, remarks that almost immediately after its publication there appeared reason to doubt the propriety of his tacit supposition that the longitude of the moon was sensibly correct. The first reason for extending the supposition of liability to error originated in Mr. Adams' theory of a diminished value of acceleration: other reasons appeared in the publication of Hansen's new Tables of the Sun, and (subsequently) in the preparation of Hansen's new Tables of the Moon. Finally, the author had been induced by the representations, first of Mr. Hind, and afterwards of Mr. J. W. Bosanquet, to examine into the time of the eclipse at the capture of Larissa, of which Xenophon has preserved a singular record; and, adopting Layard's and Capt. Felix Jones's identification of Larissa with Nimrûd, and using Capt. Felix Jones's map (with the correction of an important clerical error, which makes the longitudes too small by 1°), he had been enabled, as he conceives, incontestably to fix the date of that eclipse to −556, May 19. He therefore proceeded to treat the eclipses in the following manner.

There had been computed, with different elements for the places of the Sun and Moon, five different paths of the shadow

Digitized by Google

in the eclipse of Agathocles −309, August 14; four in that at Larissa −556, May 19; and four in that of Thales −584, May 28.

In order to reduce these, in the case of each eclipse, to a single result, the following method was used. The horary movements and parallaxes in all the calculations of one eclipse being sensibly the same, each shadow-path might be conceived as a function of the Sun's R.A. and N.P.D. and the Moon's R.A. and N.P.D. at a certain fundamental time for each eclipse. By the application of proper corrections to the Moon's R.A. and N.P.D. in every system of elements but one (Hansen's), all the shadow-paths were made functions of Hansen's Solar Elements, and of different lunar elements. And, measuring graphically the distance of each shadow-path from Hansen's shadow-path, that distance depended only on the difference of the corrected elements of the Moon in the compared shadow-path from Hansen's elements of the Moon. The distance, therefore, could be expressed by the sum of two terms, one a multiple of difference of R.A., the other a multiple of difference of N.P.D. By solution of equations the different multipliers were found, applying to each different eclipse. From these it was easy to express the shift in the position of the shadow-path in terms of changes of Moon's longitude and E.N.P.D.: and, finally, to express it in terms of an alteration in the coefficient of acceleration and an alteration in the motion of the Moon's node.

In proceeding to apply these numbers to the circumstances of the different eclipses, the author remarks that, on account of the extreme narrowness of the shadow and the definiteness of the locality where the eclipse was seen, the eclipse at Larissa ought to be taken as the cardinal eclipse. After discussion of the other eclipses, he arrives at the following conclusions:—

1. The eclipse at Larissa, −556, May 19, is established as a real eclipse at a well-defined point, and may be used for critical reference in deciding on the value of lunar tables as applicable to distant eclipses of the Moon.

2. Professor Hansen's Tables very well represent the phenomena of the three eclipses of Agathocles, Larissa, and Thales.

3. If any change in the elements of the tables is permitted, it must be in the nature of increase of the acceleration and increase in the argument of latitude in the distant ages.

4. It must now be understood that Agathocles passed on the south side of Sicily.

The author then remarks that the best prospect for further test of the Lunar Tables is to be found in the combination of the eclipse at Larissa with that at Stiklastad, A.D. 1030, Aug. 31 (*Astronomische Nachrichten*, Ergänzungs-heft, page 42): as, in both the shadows were very narrow, and the places of observation are perfectly definite; while their interval of time is very favourable for the separation of terms depending on the first power of the time from terms depending on the square of the time.

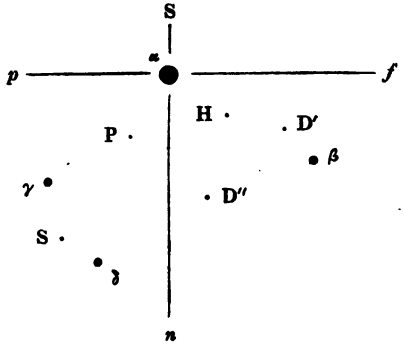
Digitized by Google

Discovery of a New Star in the Nebula of Orion.

(*Extract from a Letter addressed to Admiral Manners by M. Antoine D'Abbadie.*)

"M. Porro, our Parisian optician, has discovered a new star P in the well-known trapezium of *Orion*. It was first seen by him when trying his object-glass of 15 mètres focal length and 52 centimètres (or 20·5 English inches) in diameter. The eye-piece magnified 1200 times. The star P is certainly fainter than the stars D′ and D″. It was seen again by the same artist with his equatoreal of 4·4 mètres focal length, with an object-glass of 24 centimètres (= 9·45 English inches), and a power of 600; and lastly, on the 15th of last March, he saw again the star P in his larger refractor. The stars H and S were then visible, but D′ and D″ could not be seen. This was confirmed by another person not accustomed to observations, but who laid down at once the star P as in the accompanying sketch.

S ... Struve.
D′ and D″ ... Dumouchel.
H ... J. South.*
P ... Porro.



"As there was no ring-micrometer at hand and the faintness of the stars prevented illuminating the wires, no measures were taken, but M. Porro thinks that the relative declination of the star P is not so good as its relative R.A. The stars P, D′, D″, and S disappeared under a very faint illumination, H alone remaining then visible.

"It would, perhaps, be well to publish the above account, in order to get it confirmed by the owner of some powerful instrument.

"M. Porro has recently constructed a helioscope or telescope, so contrived as to allow observing the sun most conveniently and with any magnifying power. No dark glasses are used in the helioscope. The sun's spots appear like a spot of dark ground bared (*sic*) through a coating of snow, the sun's glare and heat being alike extinguished by this instrument, which cannot fail to be appreciated by all those who wish to investigate the physical peculiarities of the sun.

"*Königsberg*, 1857, *May* 21."

* The Editor gives Mr. D'Abbadie's plan of the trapezium, as sent in his letter, though he doubts the correctness of the position of the star H and its appended name; the more so as the well-known sixth star is omitted, which was first seen *by Sir John Herschel* while viewing the nebula *with Sir James South's refractor*.

Digitized by Google

Elements of Ariadne. By M. Pape.*

Epoch 1857, May 18·45901

M	=	315 24 3·5	
π	=	277 11 24·0	Mean Equinox 1857·0
Ω	=	264 44 32·8	
i	=	3 28 2·4	
φ	=	9 3 43·8	
Log a	=	0·342235	
Log μ	=	3·036654	
μ	=	1088″·065	

These elements were calculated from the Oxford Observations of April 15, 28, and May 6, and the Bilk Observation of May 18.

Occultation of 58 *Virginis, observed at Maresfield, in Sussex, June* 2, 1857. By Capt. W. Noble.

"The star disappeared instantaneously at $14^h\ 32^m\ 59^s{\cdot}4$ local sidereal time. Reappearance not seen. Telescope employed, my Ross equatoreal, 61 inches focal length; 4·2 inches aperture; power 74."

Occultation of α *Virginis, May* 6, 1857. By W. Huggins, Esq.

Disappearance,	9	28	54	Local S.T.
Reappearance,	10	29	3·5	—

"The moon and star exceedingly well defined. The disappearance and reappearance both apparently instantaneous and quite normal. Telescope 5 inches aperture, 5 feet focal length; power 35.

"*Upper Tulse Hill.*"

* *Ast. Nach.* No. 1087.

Digitized by Google

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich, read at the Annual Visitation of the Royal Observatory, 1857, June 6.

The following are a few extracts from this Report :—

"The foundations of the new South-eastern Dome have been laid, and I trust that the building will be completed in this summer. It is in the place which I indicated in the last Report, at the south-eastern corner of the Record Room, but not in contact with the Record Room. For explanation of the design generally, I beg leave to refer to the model which the Visitors have seen. I may here state that the local position of the building compelled me to make the entrances into the three separate stories through the middle of the North Pier. A large stove is provided for the lower story, the draft of which passes underground into the chimney of the Record Room; and I expect that this stove, by means of a trap in the first floor, will sufficiently warm and dry the second story. The dome will be drum-shaped, 29 feet in diameter inside, framed with vertical wooden standards upon horizontal curbs, and tied by diagonal iron hooping. It is to revolve on cannon-balls, and to be moved by toothed-wheel machinery carried by the dome, which acts upon a fixed rack of the wall-curb. The observing aperture will be 3 feet wide. The shutters will be two; a vertical wall-shutter, and a nearly horizontal roof-shutter, opening (for convenience of the mechanism) on opposite sides, each shutter opening independently of the other. Each shutter will carry a curved rack, to receive the action of a pinion carried by the solid parts of the dome. For the vertical shutter, I have made this rack jointed, and thereby I have been able to make the shutter flap close to the opening when it is closed, and flap close back to the dome-wall when it is opened, a condition which is not unimportant for preventing the wind from exerting any action to turn the dome. For the nearly horizontal shutter, I considered that the attempt to secure a shutter-movement of 180 degrees would introduce the necessity for the jointed rack, and would also require a complicated construction of counterpoises; and I have therefore avoided these by causing the shutter, both in its closed and in its opened state, to take a position inclined to the horizon, its angular movement being about 140 degrees; thus it will scarcely feel the wind, and the inclination will not be visible to spectators below. Other points can be explained orally. * * *

"The arrangement of the Board of Longitude papers has at last been taken up seriously, under the immediate superintendence of Mr. Main. * * * *

"In regard to the Reflex-Zenith Tube, I described in my last Report to the Visitors the construction which I proposed for destroying the tremors of the quicksilver by suspending its trough by means of straps of vulcanized caoutchouc, so as to leave it the

Digitized by Google

utmost possible freedom of motion. The construction has been perfectly successful; the tremors are absolutely destroyed, and the star has been observed at all hours of night and day. It so happened that it was observed on the very day on which it passed with the sun. In the night-observations it is found that there is a perfectly steady nucleus, occasionally with rays twirling about it; the latter evidently arise from the deranged state of atmosphere, which seems usually incidental to a zenith-sector-room; to this I shall endeavour to give attention.

"The Altazimuth is in good order. A four-glass reflecting eyepiece has been made, which will tend to the facility and accuracy of observations at great elevations. I alluded in a preceding section to the cutting away of a very small portion of one of the rays of the three-armed pier which carries the Altazimuth. The quality of the brickwork is the best that I have ever seen, and not a single brick was disturbed beyond those actually removed. Yet the effect was to give the Altazimuth an inclination of about 23″. This inclination evidently depends on the elasticity of the brickwork. The angle between the axis of the vertical circle and the axis of general revolution, which at first was pretty exactly 90° 0′ 0″, has now become, by gradual change, about 90° 0′ 14″. The magnitude of the corresponding numerical correction to every observation of azimuth induces me to contemplate a re-adjustment of some of the mechanical connexions of the instrument.

"The Barrel Apparatus for chronographic record of transits has been in constant good order. To check the occasional tendency of the pendulum to describe an unreasonably large circle (from trifling inequalities in the maintaining power, which it is difficult to suppress entirely), I have mounted a slender spring, so as to produce, when the circle is large, a light friction. As every such friction is accompanied with force directed to the centre, it deranges the time of rotation. I have, however, planned a water-resistance which would be free from this objection, and which I may perhaps adopt in this instrument. A draftsman is at present employed in making plans of the barrel apparatus.

"The Galvanic Apparatus for clock movements is in the same state as last year, five clocks being in sympathetic movement in the Observatory, one at the Hospital Schools, and one in the North Kent Station at London Bridge. That for signals has received this slight alteration, that the pull of the Time Ball Detent now alters the connexions of four triplets of springs. Of these, one controls the communications with the Electric Telegraph Company's office at Lothbury; by which hourly signals are sent on various railways; the time-balls at the Strand, Cornhill, and Liverpool, are dropped; and the Post-office clock in Lombard Street is regulated. A second affects the communications with the South-Eastern Railway Station; by which hourly signals are sent on various lines in Kent, and the time-ball at Deal is dropped, and returns its signal to acquaint us with its successful drop. The third and fourth are reserved for the prospective wants of the

Digitized by Google

Royal Dockyards; they communicate with the Admiralty wire of the British Telegraph. The communication with the Post-office clock is remarkable. At $23^h\ 26^m\ 0^s$ of that clock a signal is given to Greenwich, the comparison of which with our clock acquaints us with the error of the Post-office clock. At $0^h\ 0^m\ 0^s$ of the Greenwich clock a signal is sent from Greenwich which mechanically adjusts the Post-office clock. At $0^h\ 26^m\ 0^s$ of the Post-office clock a second signal is given to Greenwich, by which the efficiency of the adjustment is shown. I am in daily expectation of the extension of this system to three other clocks. * * *

"For the new S.E. equatoreal, the support of the north or upper end of the polar axis has been received, and is planted within the walls of the building in a position convenient for raising it to its ultimate destination. It is one piece of cast-iron, extending from about 18 inches below the floor of the room to the polar point; it weighs nearly 5 tons, and is considered to be a good specimen of Messrs. Ransomes' excellent castings. The base of the north support will be tied to the south support by horizontal iron rods under the floor. The two end-frames of the polar axis are prepared; a portion of one side of the upper end-frame is cut away, to permit uninterrupted vision as far as the pole. For moving the polar frame in right ascension, there will be an hour-circle moved by clock-work, similar to that of the Northumberland telescope, to which the polar frame may be clamped at pleasure. This hour-circle is to have a graduation at its edge to be viewed by a fixed microscope, and a graduation on its plane to be viewed by microscopes of the polar axis. The clock-work is to be driven by water power, derived from the supply-pipes, and acting by a reaction machine, as at Liverpool. I expect that, with a compensation-pendulum, with Sieman's chronometric governor, and with a proper water-resistance, as I have suggested above, I can give extreme accuracy to the motion in right ascension. For fixing the polar frame in hour-angle when transits, &c., are required, I propose a clamp independent of the hour-circle. The polar frame is to be entirely of iron, essentially on the principle of the Northumberland frame, but differing in several details, which will be best seen in the model. The declination-axis will be excentric, as explained by me last year. The clamping circle will be most conveniently carried by the polar axis, but the declination circle will be carried by the telescope, and will be viewed by two or more inclined microscopes, whose eye-ends are very close together, and very close to the pivot of the declination-axis. I anticipate that in this way the use of the declination-microscopes, ordinarily so troublesome, will be made comparatively easy. The illumination, I believe, can be conveniently thrown down the tubes of the microscopes themselves. The upper pivot of the polar axis and one pivot of the declination-axis are to be perforated for gas-pipes, and thus gaslight will be carried to every part of the frame where it may be required, even to the eye-end of the telescope.

Digitized by Google

Those persons only who have used both oil lamps and gaslights under similar circumstances can fully appreciate the enormous advantage of this arrangement. Rings for galvanic contact will be mounted on the pivot of the polar axis, and on one pivot of the declination-axis, and thus the chronographic system, and possibly the sympathetic-clock system, will be carried to the eye-end of the telescope. The telescope tube will probably be of wood. This account, with inspection of the model, will perhaps give the Visitors a clear idea of my proposals regarding the equatoreal mounting. All this work is advancing in some degree, but there is still one important drawback; I have not yet received the object-glass. Messrs. Merz have not made a new object-glass to their satisfaction; they retain, however, the first in readiness, and can at any time transfer it for temporary use, so that I consider myself justified in making every possible preparation of mounting.

"*Astronomical Observations.* — The meridional system is sacredly preserved. Each star of a large clock-star-catalogue is observed, if possible, twenty times in three years; some stars are observed for refraction; some as having been compared with the moon; some on suspicion of proper motion, &c. The moon is observed at every opportunity, without exception. The sun and planets are observed at every opportunity, except on Sundays, and except when they pass later than 15^h in the morning, in which state the large planets only are observed, and only when the moon also is to be observed. The transits have been observed almost entirely by the chronographic method, except for the close circumpolar stars.

"The whole number of meridional observations from 1856, May 19, to 1857, May 23, is as follows:—In the department of transits: Observations of transits (reckoning two limbs, or two methods of observation by ear and by touch, as two observations), 4169; observations of collimator, by the telescope of the transit-circle, 311 pairs; observations of transit-wires by reflexion, 310; observations of one collimator by the other, 52. In the department of zenith-distances (reckoning two limbs, or a combination of direct observation with reflexion observation, as two observations, and including the observations of the wire by reflexion), circle observations of all kinds, 3663. * * *

"With the altazimuth, the moon has been completely observed on 198 days. This gives 15·8 per lunation. With the transit-circle the number of complete observations is 98, giving 7·8 per lunation. Of the observations with the altazimuth, 0 are on days when the moon passed between 0^h and 1^h of solar time; 3 when between 1^h and 2^h, 7 when between 2^h and 3^h, 3 when between 21^h and 22^h, 5 when between 22^h and 23^h, 0 when between 23^h and 0^h. There are no corresponding meridional observations. The whole number of separate observations of the moon and stars is 1058, and the whole number of observations of the collimator, 812.

Digitized by Google

"A series of observations has been made for ascertaining any deviation from circularity in the form of the pivots of the vertical circle, but no sensible fault was found. * * *

"*Magnetical and Meteorological Observations.*—No change is made in the system of observations; photographic self-registration being applied to the principal magnetical and meteorological instruments, pencil self-registration being applied to the wind and rain, and eye-observations being intermingled for zeros. Commencing with 1856, August 25, the thermometers in the magnet-boxes have been read at twenty-four consecutive hours once in every week, with the view of obtaining bases for complete reduction of the observations. The regular observations of the maximum and minimum thermometers in the Thames have been interrupted, as has been stated above, but I hope that arrangements may be made for their restoration. * * *

"Mr. Main's examination of Bessel's Refraction Tables, to which allusion was made in the last Report, is completed; it shows that the correction required, though small, is distinct. The temperature coefficient can scarcely be improved.

"The account (by myself) of the construction of the national standards of length is completed.* Some supplementary works relating to the equipment of the Exchequer Office still require attention.

"The British Government had for some years past contributed by pecuniary grants to the preparation of Professor Hansen's Lunar Tables. In the last winter they undertook the entire expense of printing a large impression of the Tables. The reading of the proof-sheets (a very considerable labour) has been effected entirely at the Observatory. I may take this opportunity of stating that the use of these Tables has enabled me, as I think, incontestably to fix the capture of Larissa to the date B.C. 556, May 19. This identification promises to prove valuable, not merely for its chronological utility, but also for its accurate determination of an astronomical epoch, the point eclipsed being exactly known, and the shadow having been very small. Several calculations have been made in reference to this and the two other ancient eclipses (of Agathocles and Thales), which I am now preparing to combine in one system of calculation."

Formulæ of Navigation and Nautical Astronomy. Arranged by Capt. Charles F. A. Shadwell, R.N., C.B. London, 1856.

These formulæ are exhibited on a series of twelve cards, enclosed in a pocket-case. Each formula is accompanied by an explanatory statement which is in most cases illustrated by means of a simple diagram. The selection of formulæ includes all those which are required for the solution of the working problems of

* A paper on this subject by the Astronomer Royal has been recently communicated to the Royal Society.—R. G.

Digitized by Google

navigation. To those who prefer the use of algebraic expressions to the diffuse language of a verbal precept, this publication will, no doubt, prove very serviceable; while others may be stimulated by it to extend their acquaintance with the processes of mathematical science, which would give them a mastery over the formulæ otherwise unattainable.

Dr. Rudolph Wolf, of Berne, in a letter to the Editor of the *Astronomische Nachrichten*, mentions that he has prepared for the press a paper on the Solar Spots, which will shortly appear in a Zurich periodical. This paper will contain a catalogue of 1131 observations of the solar spots by Staudacher of Nürembürg, extending over the period included between the years 1749 and 1799. From an examination of this catalogue, Dr. Wolf obtained the following results exhibiting the relative numbers of spots for each of the various years to which the observations refer.

Year.	Rel. Number of Spots.	Year.	Rel. Number of Spots.	Year.	Rel. Number of Spots.
1749	31·9	1766	16·1	1783	10·9
50	34·6 Max.	67	16·6	84	2·2 Min.
51	19·4	68	26·1	85	8·9
52	16·4	69	42·5 Max.	86	30·4
53	11·3	70	39·7	87	46·4 Max.
54	2·2	71	36·6	88	45·3
55	0·0 Min.	72	24·6	89	39·4
56	6·4	73	16·0	90	37·6
57	8·2	74	11·0	91	22·8
58	22·2	75	5·8	92	21·7
59	24·0	76	0·0 Min.	93	17·0
60	25·1	77	39·3	94	0·0
61	37·5 Max.	78	49·9 } Max.	95	2·0
62	25·3	79	49·6 }	96	12·0
63	18·7	80	36·3	97	0·0
64	19·1	81	35·2	98	0·0
65	11·5 Min.	82	14·3	99	0·0 Min.

Dr. Wolf states that the same publication will contain a series of very careful observations of the solar spots, by Zucconi, for the years 1754–57, from which he has deduced the following relative numbers:—

Year.	Rel. Number of Spots.
1754	9·9
55	5·2
56	6·7
57	19·7

Both series of observations, Dr. Wolf adds, corroborate the

Digitized by Google

conclusion arrived at by him in 1852, which placed the epoch of minimum in the year $1755 \pm 0^{\circ}5$.

Elements of Planet (44). By M. Pape.*

Epoch 1857, June 15·5. M.T. Berlin.

M	=	68° 40′ 46″·2	
π	=	118 48 14·4	Mean Equinox 1857·0
Ω	=	127 5 57·5	
i	=	3 53 26·1	
φ	=	26 57 40·8	
Log a	=	0·427627	
Log μ	=	2·908567	

These elements were calculated from two Vienna observations of June 9 and June 12, and from a Bonn observation of June 15. The following are the two last-mentioned of these observations:—

			R.A.	Decl.
1857, June 12	11h 2m 46s·9	Vienna M.T.	226° 13′ 13″·8	− 11° 51′ 11″
15	10 11 51·0	Bonn M.T.	225 50 57·6	− 11 50 43·3

M. Pape has also calculated an ephemeris of the planet extending from June 25 to July 23.

New Comet.

The following telegraphic dispatch, announcing the discovery of a new comet at Göttingen by M. Klinkerfues, was received at the Royal Observatory, Greenwich:—

"A comet discovered by M. Klinkerfues at Göttingen.

Göttingen Mean Time.

June 22, $13^h\ 28^m\ 6^s$

Right Ascension 55° 6′

Declination 39°

Professor Challis has forwarded the following observation of the comet made at Cambridge:—

1857, June 24, $13^h\ 48^m\ 3^s{\cdot}1$ G.M.T.

R.A. $3^h\ 40^m\ 10^s{\cdot}95$

N.P.D. 48° 0′ 24″·9

* *Ast. Nach.* No. 1092.

Digitized by Google

CONTENTS.

	Page
Fellows elected	223
Presentation by Miss Sheepshanks, of the Astronomical and Scientific Instruments which belonged to her late brother, the Rev. R. Sheepshanks	ib.
Discovery of a New Planet, by M. Goldschmidt	ib.
Observations of Small Planets at the Royal Observatory	224
Observations of the Stars in the Nebula of *Orion*, by M. Otto Struve ...	225
Photographical Experiments on the Positions of Stars, by Mr. Bond ...	230
Oral Address, by the Astronomer Royal	233
On the Variable Star, R *Leonis*, by Mr. Baxendell	235
On the Effect of Local Attraction in Modifying the Apparent Form of the Earth, by Lieut. Tennant, Bengal Engineers	236
Extract of a Letter from M. Schwabe to Mr. Carrington	241
Report of the Syndicate appointed to Visit the Cambridge Observatory ...	ib.
On the Eclipse of Agathocles, the Eclipse at Larissa, and the Eclipse of Thales, by the Astronomer Royal	243
Discovery of a New Star in the Trapezium of *Orion*, by M. Porro... ...	245
Elements of *Ariadne*, by M. Pape	246
Occultation of 58 *Virginis*, by Capt. Noble	ib.
" *a Virginis*, by Mr. Huggins	ib.
Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory...	247
Formulæ of Navigation and Nautical Astronomy, by Capt. Shadwell ...	251
On the Solar Spots, by Dr. Rudolph Wolf	252
Elements of Planet (44), by M. Pape	253
Discovery of a New Comet, by M. Klinkerfues	ib.

London :—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, July 3, 1857.

Digitized by Google

ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *July* 10, 1857. No. 9.

Rev. R. MAIN, Vice-President, in the Chair.

Arthur Cayley, Esq. F.R.S., 2 Stone Buildings, Lincoln's Inn;
Rev. W. H. Drew, Blackheath, Proprietary School; and
J. J. Sylvester, Esq., 26 Lincoln's Inn Fields,

were balloted for and duly elected Fellows of the Society.

Note on the Eclipses of Agathocles, Larissa, and Thales. By the Astronomer Royal.

The Astronomer Royal has been enabled, by the kindness of Professor Hansen, to make an important addition to his investigations on the eclipses of Agathocles, Larissa, and Thales. Professor Hansen having computed, from the same tables which were adopted as fundamental in the preceding inquiry, the path of the shadow in the eclipse at Stiklastad, the Astronomer Royal has combined it with the eclipse at Larissa, and finds from this combination that Professor Hansen's coefficient of secular acceleration must be increased by a quantity differing little from $0''.755$. The argument of latitude must also be increased by $45''$ nearly multiplied into the number of centuries anterior to 1800. The four eclipses are thus brought into perfect harmony. Professor Hansen's coefficient of tropical secular acceleration is $13''.301$, including $1''.121$ due to the secular acceleration of precession of the equinoxes. By the increase above mentioned, the coefficient of tropical secular acceleration is raised to $14''.056$, and that of sidereal secular acceleration to $12''.935$.

Observations in the Saturnian System. By Capt. W. S. Jacob.

"I beg to submit to the notice of the Society a portion of the results of my observations on the Saturnian System. Those of *Titan* have been reduced, numbering 67 sets of measures of angle, and 54 of distance. Of these latter 20 were taken within 15° (in longitude) of elongation, and will be proper for determining the value of the semi-major axis; but 3 of them were taken with the old micrometer furnished by Lerebours along with the instrument: a better one by Dollond being now generally em-

Digitized by Google

ployed, which is somewhat rickety, and should in my opinion be rejected; but it happens to be of little consequence to the result whether they are included or not. The following corrected elements have been deduced, those marked (A) from the angles alone, and those marked (A + D) from the angles and distances combined. The latter are, of course, the best; but the difference is very trifling. In the epochs the light equation is included; *i.e.* in employing them the light equation must be first deducted from the time of observation.

For 1857·00, Mean Time at Greenwich.

	A.	A + D.
	° ′	° ′
ι =	299 45·1	299 46·2
i =	27 36·7	27 36·0
Ω =	167 58·6	168 0·0
e =	·027996	·027953
ϖ =	257° 22′·4	256° 51′·2

The orbit seems inclined to the plane of the ring by 36′, supposing Bessel's elements of the latter to be correct.

The following values of a^* have been deduced,—

No. (1) from the whole 54 measures;

No. (2) from the 20 elongations; and—

No. (3) from 17 elongations, rejecting the 3 suspected measures above alluded to.

(1)	176″·895
(2)	176·927 ± ·07
(3)	176·886 ± ·07

It is manifestly of little importance which of these be adopted as the true value; and we may safely take 176″·90 as being within less than 0″·1 of the truth. The mean motion may be considered as very exactly known, since my epoch differs by only 7^t from Bessel's. The error cannot, therefore, well exceed 0′·5 per annum, or $\frac{1}{1,000,000}$ of the whole; taking then the daily motion 22°·577008, the value of *Saturn's* mass will be = ·00028765 or $\frac{1}{3476·4}$ if we adopt Bouvard's value of the mean distance, viz. 9·54301; or if we prefer Bessel's (9·542189), the value will be =·00028759 or $\frac{1}{3477·1}$

These values are uncorrected for perturbations; but the effect of these must be very small; the ring and protuberant equator will tend to increase the apparent mass, while the solar attraction will diminish it. I shall be able to form a better judgment as to whether the *balance* of effect is sensible or not, when the observations of the remaining satellites have been reduced.

* Semi-major axis reduced to *Saturn's* mean distance.

Digitized by Google

The details of these observations will be printed hereafter; but I thought an abstract of the results might be interesting in the meantime.

I should mention that the value of the micrometer scale has been very well determined; last year I made another attempt to ascertain the temperature-coefficient, but failed for want of a sufficient range of temperature; the resulting values of one revolution were—

	Temp.
	°
23″·2682 ± ·0029	70·7
23·2649 ± ·0049	89·9
Mean 23·2665 ± ·0029	80·3

The temperature-correction should have had the opposite sign to that indicated by these observations; but the difference is accounted for by the amount of the probable error. The mean value must be pretty correct, and the temperature-correction is of no consequence here, as the temperature at the time of observation never differs more than a few degrees from 80. Any uncertainty of this kind could not well produce an error in *Titan's* elongation exceeding 0″·04, and may therefore be considered insensible.

Observatory, Madras.

New Double Stars discovered by Mr. Alvan Clark, Boston, U.S.; with appended Remarks, by the Rev. W. R. Dawes.

No.	Designation.	R.A.	N.P.D.	Mag.	Approx. Dist.	Tel. of Discovery.	Date of Discovery.
		h m	° ′		″	Inch.	
1	* Andromedæ	0 13·5	57 49	7, 7	0·4	7⅛	Oct. 1856
2	95 Ceti	3 10·7	91 29	5½, 10	0·8	7½	20 Dec. 1853
3	Weisse's Bessel, vi. 109	6 4·3	94 38	6½, 9	1·1	7½	6 Feb. 1854
4	Weisse's Bessel, vi. 1291	6 42·2	104 59	6, 9	1·0	4¾	17 Feb. 1852
5	8 Sextantis	9 45·1	97 24	6, 6½	0·6	4¾	7 April, 1852
6	* Corvi	12 0·3	109 32	6		4¾	19 May, 1852
7	μ Herculis, B. & C.	17 40·6	62 11	10½, 11	1·8	7⅛	July, 1856
8	* Herculis	17 47·4	60 17	8¾	0·3	7⅛	July, 1856
9	* Herculis	17 48·7	60 9	10, 10½	1·1	7⅛	July, 1856
10	21 Sagittarii	18 16·4	110 37	5, 8	2·5		
11	Weisse's Bessel, xviii. 391	18 17·2	91 39	7, 7¼	0·5	7¼	30 July, 1854
12	Weisse's Bessel, xix. 1273	19 50·6	92 38	7¼, 8	0·9	7¼	18 July, 1854

Digitized by Google

"The places of these difficult objects have been from time to time communicated to me in letters from their discoverer, who has adopted the plan of testing the efficiency of his object-glasses when completed by sweeping for *new* double stars of the last degree of difficulty, rather than by the examination of objects whose character was previously known. At first, under the impression that every such object in the northern hemisphere visible with telescopes of moderate aperture must already have been picked up and registered during the careful examinations of that portion of the heavens by the Struves with the Dorpat refractor of 9·6 inches' aperture, and with the Poulkova of 15, Mr. Clark confined his search to the southern hemisphere; and his diligence and skill were rewarded by the discovery of several interesting objects, which, it might be supposed, would hardly have escaped the Dorpat telescope if they had been as decidedly double in 1826 as they are now. Latterly, however, having ventured to extend his researches northward, he has made some discoveries which are almost startling (especially the duplicity of the very minute companion of μ *Herculis*), and are sufficient to show that there is much which may be achieved by a diligent use of instruments of moderate dimensions, provided they are also of extreme perfection. A few notes on some of the most interesting of these objects may not, perhaps, be unacceptable.

"1. This star has a good altitude at Poulkova, and its magnitude entitles it to a place in Otto Struve's catalogue. Its omission there may reasonably lead to a suspicion that it has a binary character, and has of late years come out from a state of apparent singularity. I have obtained an approximate measure of this star, but have not examined it under sufficiently favourable circumstances.

"2. Of 95 *Ceti* I have repeatedly obtained measures; but it is a delicate object; and from its moderate altitude here requires fine circumstances. The small companion, which has a purplish tint, is faint and close, and may, therefore, have easily escaped detection at Dorpat.

"5. Notwithstanding the moderate meridional altitude of 8 *Sextantis* at Dorpat (about 24°), it may reasonably be doubted whether its duplicity would have been left to be discovered with a $4\frac{3}{4}$-inch object-glass, however perfect, if no change had occurred in its appearance since Struve's scrutiny of that part of the heavens.

"7. The position and distance of the small star with respect to μ *Herculis* were observed by Struve at Dorpat on one night in 1829, on two nights in 1832, and on three in 1836; and also on one night at Poulkova with the 15-inch refractor in 1851. Yet no suspicion was recorded on any occasion of the companion being double. It is, therefore, truly astonishing that Mr. Alvan Clark should have detected its unsuspected duplicity with an object-glass whose aperture is only $7\frac{3}{4}$ inches! I have succeeded in measuring it pretty well in position, but only approximately in dis-

Digitized by Google

tance; the faintness of the components almost forbidding the slightest illumination, though they bear a high power on Clark's 8-inch object-glass,—about 700 suiting them best. My results are P = 58°·97; D = 1″·85 ±. It has been shown by Struve (*Pos. Mediæ*, p. ccxvii.) that μ and its companion have a common proper motion; so that in this respect they are similar to μ and μ^2 *Boötis;* and as the companion of μ *Herculis* has now been discovered to be *double*, it only remains that it should prove to be *binary* to render the resemblance complete. It is, therefore, earnestly commended to the attention of those observers who possess telescopes competent to deal with it. As the small star *precedes* the large one, the former is properly μ^1, and the latter, μ^2, if that nomenclature be adopted.

" 8. This star is about as difficult as the closest of the Poulkova catalogue; and though on a fine night elongated with the 8-inch object-glass I now have in use, would require the full power of a 15-inch refractor fairly to divide it. That it attracted Mr. Clark's attention as a double star is sufficient to prove that his eye as well as his telescope must possess extraordinary power of definition.

" 9. This double star forms a good introduction to the small one of μ *Herculis;* its components being brighter by about half a magnitude of my scale. With my 8-inch object-glass and power 697, I have obtained, P = 229°·48; D = 1″·119.

" 11. A very difficult object, though decidedly elongated with a 7½-inch aperture. My measures in 1854 gave, P = 178°·10; D = 0″·425, the latter a mean of two estimations.

" 12. A neat and not very difficult object; it ought certainly to have been seen at Dorpat if it were as separate then as it is now. My measures with Clark's 7½-inch object-glass gave in 1854, P = 333°·76; D = 0″·863."

"*Haddenham, Thame, July* 9, 1857."

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Month of June, 1857.

(*Communicated by the Astronomer Royal.*)

Phocea.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, June 17 13 24 55·3	19 9 52·16	72 58 0·61
22 13 2 23·1	19 6 59·07	71 40 35·90
24 12 53 13·6	19 5 41·15	71 13 0·26
26 12 44 0·2	19 4 19·37	70 47 32·54
27 12 39 21·9	19 3 36·93	70 35 33·41

Digitized by Google

Lætitia.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1857, June 1	11 31 34·8	16 13 8·12	95 7 8·68
2	11 26 49·2	16 12 18·31	95 5 32·04
8	10 58 23·6	16 7 27·37	94 59 7·99
12	10 39 37·9	16 4 24·88	94 57 50·19
13	10 34 58·0	16 3 40·72	94 57 54·50
15	10 25 41·4	16 2 15·76	94 58 25·64
17	10 16 27·9	16 0 53·80	94 59 36·76
22	9 53 42·6	15 57 47·54	95 5 9·12
23	9 49 12·6	15 57 13·39	95 6 41·51
24	9 44 43·9	15 56 40·52	95 8 21·48

On the Application of the Formulæ for Precession in the case of Stars near to the Pole; with a Correction of a trifling Error in the Table given by Mr. Baily in the Preface of the B.A. Catalogue. By R. C. Carrington, Esq.

In the exposition of the formulæ of Bohnenberger, given by Bessel in the *Tabulæ Regiomontanæ*, and elsewhere; although it has manifestly been the aim to attain the utmost brevity, it does not appear to have been noticed that the expressions for the auxiliary angles

$$(z+\lambda),\quad (z'-\lambda'),\quad \text{and } \theta,$$

may be given in formulæ involving only the times and constants, in all cases in which the tangent of the angle $\frac{1}{2}(\psi-\psi)$ does not sensibly differ from its circular measure, cases which include all those commonly occuring. Thus, for Bessel's constants, if the star have to be brought from y to y', and $t=y-1750{\cdot}0$, and $t'=y'-1750{\cdot}0$,—

$$\begin{aligned}
z+\lambda &= +23''{\cdot}0144\,(t'-t) - 0''{\cdot}0115\,(t'+t) - 0''{\cdot}000056\,.\,t'^2 - 0''{\cdot}000210\,.\,t^2\\
z'-\lambda' &= +23''{\cdot}0144\,(t'-t) + 0''{\cdot}0115\,(t'+t) + 0''{\cdot}000210\,.\,t'^2 + 0''{\cdot}000056\,.\,t^2\\
\theta &= +20''{\cdot}0652\,(t'-t) \qquad \ldots\ldots \qquad - 0''{\cdot}000048\,.\,t'^2 + 0''{\cdot}000048\,.\,t^2
\end{aligned}$$

Expressed thus, we perceive at once that Mr. Baily has fallen into error in assuming, in page 40 of the Preface of the B.A.C., that for 1850·0 the values of $z+\lambda$ and $z'-\lambda'$ are each evanescent, as well as in stating that their variations are uniform. In fact, the differences are nearly constant, and for 1850·0 the terms $(z+\lambda)+(z'-\lambda')$ cancel one another. The oversight introduces a discontinuity in the values tabulated, which perplexed me, in

Digitized by Google

following so careful a person as Mr. Baily, till I perceived the nature of his mistake. Although the error arising from his assumption would in most cases be exceedingly small, it may be worth while to give the table in a correct form.

Precession-Constants (*Bessel's Elements*).

From 1850·0 to	$(z+\lambda)$	$(z'-\lambda')$	θ
	′ ″	′ ″	′ ″
1800	−19 14·69	−19 7·91	−16 42·90
1810	−15 24·72	−15 17·42	−13 22·30
1820	−11 34·76	−11 26·89	−10 1·71
1830	− 7 44·82	− 7 36·31	− 6 41·13
1840	− 3 54·88	− 3 45·70	− 3 20·56
1850	− 0 4·96	+ 0 4·96	0·00
1860	+ 3 44·95	+ 3 55·66	+ 3 20·55
1870	+ 7 34·85	+ 7 46·40	+ 6 41·09
1880	+11 24·74	+11 37·19	+10 1·62
1890	+15 14·62	+15 28·02	+13 22·15
1900	+19 4·49	+19 18·88	+16 42·66

It is plain that Mr. Baily computed the values for 1800 and 1900 correctly, and then went wrong as I have pointed out.

Some may now prefer using the constants, which result from the elements adopted by Peters, and given on page 71 of his *Num. Const. Nutations.* We then have (counting t and t' from 1800·0)

$$z+\lambda = +23''\cdot0311\,(t'-t) - 0''\cdot0000497\,.\,t'^2 - 0''\cdot0001922\,.\,t^2$$
$$z'-\lambda' = +23''\cdot0311\,(t'-t) + 0''\cdot0001922\,.\,t'^2 + 0''\cdot0000497\,.\,t^2$$
$$\theta = +23''\cdot0611\,(t'-t) - 0''\cdot0000432\,.\,t'^2 + 0''\cdot0000432\,.\,t^2$$

which furnish us with the following—

Precession-Constants by Peters' Elements.

From 1850 to	$(z+\lambda)$	$(z'-\lambda')$	θ
	′ ″	′ ″	′ ″
1800	−19 12·03	−19 11·43	−16 42·94
1810	−15 21·73	−15 21·10	−13 22·35
1820	−11 31·43	−11 30·73	−10 1·76
1830	− 7 41·15	− 7 40·32	− 6 41·16
1840	− 3 50·87	− 3 49·88	− 3 20·57
1850	− 0 0·61	+ 0 0·61	0·00
1860	+ 3 49·65	+ 3 51·13	+ 3 20·56
1870	+ 7 39·89	+ 7 41·69	+ 6 41·11
1880	+11 30·13	+11 32·29	+10 1·66
1890	+15 20·35	+15 22·93	+13 22·20
1900	+19 10·57	+19 13·60	+16 42·73

It is to be regretted, in my humble opinion, that the use of these direct and exact formulæ is not commonly preferred to the use of secular variations derived by their expansion in series. It

Digitized by Google

appears that this arises in great measure from an apparent obstacle presented by the troublesome computation of the value of

$$\tan (A' - A) = \frac{\sin A \,.\, \sin \theta \,(\operatorname{cotan} \delta + \tan \tfrac{1}{2}\theta \,.\, \cos A)}{1 - \cos A \,.\, \sin \theta \,(\operatorname{cotan} \delta + \tan \tfrac{1}{2}\theta \,.\, \cos A)};$$

which undoubtedly looks repulsive enough for daily use. But as Mr. Baily has observed, the second term within the brackets may in almost all cases be neglected; and, as I beg to add, the computations greatly facilitated by the arrangement of the term thus,—

$$p = \sin \theta \,.\, \operatorname{cotan} \delta.$$

$$\tan (A' - A) = p \,.\, \cos A \,.\, \frac{1}{1 - p \,.\, \cos A} \,.\, \tan A;$$

the factor, $\log \frac{1}{1 - p \,.\, \cos A}$ being extracted at sight from a small table of 5-figure logarithms of the quantities,—

$$\text{Log } n, \quad \text{Log } \frac{1}{1+n}, \quad \text{Log } \frac{1}{1-n},$$

with the argument $\log p \,.\, \cos A$.

Such a table, similar but different to the Gaussian logarithms, will be found of use in an observatory in many other instances.

Results of the Measures of γ Virginis for the Epoch 1857, *as Determined by Rear-Admiral Smyth, at the Hartwell Observatory, with a Double-wire Micrometer, under a power of* 340.

Date (t)	Position. $\angle$	Weight. w	$w(\angle - 170°)$	$w(t.-1857)$	Observations.	Distance. Δ	w	$w.\,\Delta.$	Observations.
1857·38	171° 29′	62	+ 5518	2356	10	3″·3378	31	103″·472	7
— ·38	171 13	46	+ 3358	1748	8	3·5661	12	42·793	4
— ·40	170 20	24	+ 480	960	4	3·5443	24	85·063	6
— ·41	170 23	20	+ 460	820	4	3·5680	17	60·656	5
— ·42	169 59	44	— 44	1848	6	...	...	...	...
— ·43	170 31	30	+ 930	1290	6	3·4927	23	80·332	6
— ·45	170 39	25	+ 975	1125	5	3·4827	28	97·516	6
— ·47	170 11	18	+ 198	846	4	3·5382	12	42·458	4
— ·47	169 28	34	— 1088	1598	6	3·4531	24	82·874	6
		303	+ 10787	12591	53		171	595·164	44

Conclusion.

Sum of ($\angle$ *s. w.*), ∴ mean of Position = 170°35′·6.

Sum of ($\angle$. *w.*), ∴ mean of Distance = 3″·4804.

Sum of (w . *t.*), ∴ mean of Epoch = 1857·415.

Digitized by Google

At the request of Admiral Smyth the following epochs were communicated to him by the observers whose names are respectively attached:—

	Position.	Distance.	Epoch.
	°	″	
Airy	173·0	3·64	1856·96
Wrottesley	171·36	3·665	1856·97
Dawes (*double image*)	170·08	3·586	1857·35
Dawes (*wire mic.*)	169·93	3·561	1857·42
Fletcher	171·55	3·537	1857·41

Observations of Comet III. 1857. By Dr. Donati.

(*Communicated by Mr. Drach.*).

	Florence M.T.	Comet — Star. R.A.	Comet — Star. Decl.	No. of Comparisons.	Comet's App. R.A.	Comet's App. Decl.
	h m s	m s	′ ″		h m s	° ′ ″
June 28	14 34 36	+1 20·78	— 5 51·1	2 with (*a*)	4 16 30·36	+45 42 46·[illegible]
	14 55 27	+5 26·59	−26 7·0	2 with (*b*)	4 16 39·95	+45 43 7·[illegible]

Mean Position of Comparison Stars for 1857.

	R.A.	Decl.	
	h m s	° ′ ″	
(*a*)	4 15 9·58	+45 48 33·3	Lalande 8163–64
(*b*)	4 11 13·15	+46 9 10·0	B.A.C. 1323

Elements of Comet III. 1857. By M. Pape.

T	=	July 18·01175, M.T. Berlin, 1857.
π	=	249 37 39·8 } Mean Equinox 1857·0
Ω	=	23 40 58·6 }
i	=	58 59 32·2
Log q	=	9·565259

Motion retrograde.

These elements were calculated from the Berlin Observations of June 23 and July 3, and the Altona Observation of July 14.

Discovery of New Planets.

New Planet discovered by M. Goldschmidt.

On the 28th of June, M. Goldschmidt discovered a new planet at Paris. This forms the forty-fifth of the group of minor planets. The following elements have been calculated by Dr. Forster:—

Digitized by Google

Epoch	.....	1857, July 8·5000
		° ′ ″
M	.....	44 19 29·6
ϖ	.....	208 16 39·4
Ω	.....	148 19 38·2
i	.....	6 34 52·6
φ	.....	5 14 44·0
log a	.....	0·430856
μ	.....	801″·1664

These elements were calculated from the following positions:—

	M.T. Berlin.	R.A.	N.P.D.
	h m s	° ′ ″	° ′ ″
July 2	11 36 24	245 27 26·2	− 11 52 29·1
8	12 0 22	244 54 52·5	− 12 9 15·9
14	11 43 9	244 36 34·1	− 12 29 16·2

New Planet discovered by Mr. Pogson.

On the 16th of August, the forty-sixth of the minor planets was discovered by Mr. Pogson at the Radcliffe Observatory. The following position is given for the evening of discovery:—

	M.T. Oxford.	App. R.A.	App. Dec.
1857, Aug. 16	$9^h\ 49^m\ 10^s$	$20^h\ 20^m\ 27^s{\cdot}16$	$-16°\ 20'\ 53''{\cdot}7$

From this observation and from the Berlin observations of August 28 and September 8, M. Pape has calculated the following elements:—

Epoch, August 16·5, 1857, M.T. Berlin.

		° ′ ″
M	.....	334 46 12·5
ϖ	.....	344 56 16·9
Ω	.....	181 30 45·9
i	.....	2 17 46·8
φ	.....	7 2 34·0
log a	.....	0·390385
log μ	.....	2·964430

New Planet discovered by M. Luther.

Another planet, numbering the forty-seventh of the group between *Mars* and *Jupiter*, was discovered by M. Luther at the Observatory of Bilk on the 15th of September. The following position was taken on the same evening:—

M.T. Bilk.

1857, Sept. 15 $12^h\ 29^m\ 16^s{\cdot}4$ α (47) $0°\ 49'\ 40''{\cdot}0$ δ (47) $-0°\ 42'\ 35''{\cdot}0$

Daily motion $-12'{\cdot}7$ $-3'{\cdot}2$

The star of comparison (8·9) was thus taken according to Bessel's zone 112 and 136:—

Apparent Place for Sept. 15.		Mean Place 1857·0.	
$0°\ 32'\ 14''{\cdot}9$	$-0°\ 42'\ 58''{\cdot}8$	$0°\ 31'\ 22''{\cdot}7$	$-0°\ 43'\ 21''{\cdot}6$

Digitized by Google

Two New Comets.

On the evening of the 28–9th of July a new comet (Comet IV. 1857) was discovered by M. Dien, at the Imperial Observatory, Paris. The same comet was also discovered independently, by Professor Habicht, at Gotha, on the evening of the 30th of July. The latter remarks that at the time of its discovery the diameter of the comet was about 3′, but it appeared of a loose, uniform structure, and very faint. Observations of this comet by Dr. Trettenero will be found at page 268.

Elements of Comet IV., 1857. By Dr. Bruhns.

T	= August 23·63288	
π	= 21 16 29·2	Mean Equinox 1857·0
Ω	= 201 29 33·6	
i	= 32 33 58·7	
Log q	= 9·874808	

Motion direct.

This comet was also discovered independently by Dr. Peters at the Dudley Observatory in Albany, U.S., as appears from the following letter addressed by Dr. Gould, the Director of the Observatory to the Editor:

(*Letter from Dr. Gould to the Editor.*)

"I have the honour to announce to you the discovery of a comet at the Dudley Observatory in Albany, by Dr. C. H. F. Peters, who has obtained the following position with the ring-micrometer of the comet-seeker, none of the large instruments having yet been mounted:—

	Albany S.T.	Comet's R.A.	Comet's Decl.	No. Comps.
	h m s	h m s	° ′ ″	
1857, July 25	20 5 51·0	3 33 32·9	+59 9 14	10
26	21 7 20·8	3 46 26·1	+58 18 33	

"The comparison star was Oeltz Argel 3999, 4000 at the first, and Oeltz Argel 4278 at the second observation; the differences being uncorrected for refraction.

"The comet is exceedingly faint, and without visible nucleus.

"*Cambridge*, 1857, *July* 27."

On the 20th of August a new comet (Comet V., 1857) was discovered by M. Klinkerfues at Göttingen. The following elements were calculated by Dr. Bruhns:—

Digitized by Google

T	=	1857, September 30·85270 Berlin M.T.
		° ′ ″
ϖ	=	250 21 18·5
Ω	=	14 46 30·3
i	=	56 18 16·0
Log *q*	=	9·752190

Motion retrograde.

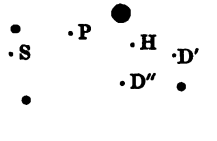
These elements have a distant resemblance to the elements of Comet III., 1790, and Comet I., 1825.

Note on the Star recently Discovered in the Trapezium of the Nebula of Orion. By M. Abbadie.

(*Letter to Mr. Carrington.*)

"When writing on the 21st ult. to Admiral Manners, to thank him for getting the *Monthly Notices* sent to me, I informed him of the discovery of a ninth star in the trapezium of the nebula of *Orion*, made by M. Porro in Paris with his 52-centimètre refractor. I then called it the eighth star, having overlooked the star H discovered by Herschel (Sir John, I believe). I then invited other astronomers to search for and confirm the new discovery. Father Secchi has now made the following communication, which I translate from the extract of his journal, dated February 10, 1857:—

"'Air excellent; the sixth star (H) of the trapezium is not visible, although the atmosphere is beautiful. Why? In place of it, I think I see a small star in the centre of the trapezium.' The Roman astronomer then says that, like M. Porro, he found great difficulty in seeing the stars D″ and D′. He takes the latter for the companion of H, which Sir J. South had already mentioned as a double star.



"I believe that there is in England no refractor with an aperture of 52 centimetrès, or 19·2 old Parisian inches; but Father Secchi's observation shows that good and relatively small refractors may, on chosen nights, show this very faint test-object. The position and distance of the star P have not yet been referred by measurement to one of its neighbours.

"*Königsberg, Prussia*, 1857, *June* 17."

On the Variability of 30 *Herculis.* By Josh. Baxendell, Esq.

In October and November 1855, 30 *Herculis* was almost invisible to the naked eye, even on the finest nights; and the mean

Digitized by Google

of several comparisons with other stars, made at different times, gave its magnitude =5·9. It is now, however, a conspicuous star, and not less than 4·9 magnitude,—the mean of several nights' estimations since June 18 being 4·85. Professor Argelander rated this star 5·6 magnitude, or less than *v*, 52 and 42 *Herculis;* but it is now brighter than any of these stars. On the other hand, it appears from the *Radcliffe Observations* of 1851 that it was of the 4·8—5·0 magnitude at the end of June and beginning of July of that year. It is very probable, therefore, that its light is subject to periodical changes; but the observations hitherto made are not sufficient to afford even a rough approximation to the length of the period. The red colour which is so common amongst the variable stars (especially those of long period) is also very decided in this star.

Manchester, July 7, 1857.

Discovery of two New Planets. By M. Goldschmidt.

(*Extract of a Letter to Mr. Hind.*)

"I have the pleasure to announce to you the discovery of two new planets (the forty-eighth and forty-ninth) which I made on the same evening, viz. the 19th of this month. Whilst I was engaged in observing the 48th, I neglected the investigations relative to a star which had vanished in the vicinity of *κ Aquarii*, but late in the evening my attention was directed to a star which turned out to be the planet. On the 20th and 21st I found that it had shifted its position, whereupon I took its place micrometrically, and have the honour to communicate to you the results.

(48) Planet, Sept. 19, 10^h, Graph. Posit. R.A. $22^h\,27^m\,11^s$, $-5°\,52'$

			R.A.		
		h m	h m s	° ′	
(48)	Sept. 20	12 7	22 26 31	−5 57·5	(the Decl. at $11^m\,28^s$)
(48)	Sept. 22	11 5	22 24 25·4	−6 7·8	
(49)	Sept. 21	9 37	22 28 28·8	−5 4	
(49)	Sept. 22	8 24	22 27 55	−5 8·5	

"I wanted time to calculate and add the precession of the star of comparison from 1857·0 to the epoch of the constants. The 48th resembles a star of the 11th magnitude: the 49th I found to change in brightness from 10 to 11.12 magnitude. I shall be glad if you will be so kind as to communicate this intelligence to the Royal Astronomical Society."

Digitized by Google

Observations of Comet IV. 1857, *made at the Royal Observatory, Padua, by Dr. Virgilio Trettenero.*

(*Extract of a Letter from Professor Santini, of Padua, to the Astronomer Royal, dated* 1857, *August* 30.)

Month and Day.	Padua M.S.T.	App. R.A. of Comet.	App. Decl. of Comet.	No. of Comparisons.	Star of Comparison.
	h m s	h m s	° ′ ″		
Aug. 18	14 30 51·8	6 37 24·49	+29 6 6·8	6	B.A.C. 2197
22	14 28 40·8	6 55 6·95	23 58 22·0	3	B.A.C. 2350
25	14 39 52·9	7 7 23·86	20 21 7·0	5	B.A.C. 2423
27	14 44 31·6	7 15 11·24	+18 4 9·6	4	Bess. Z. 281

The apparent position of Bessel's star is as follows:—

R.A. = $7^h\ 18^m\ 46^s{\cdot}04$ Decl. = $+18^\circ\ 10'\ 22''{\cdot}1$

In the reductions corrections have been applied for the difference of refraction.

On a Method of finding the Distance of a Planet from the Earth. By Professor De Gasparis.

(*Extract of a Letter to Mr. Hind.*)

"I beg of you to insert in the *Monthly Notices* the following note:—

"'The reader is acquainted with the curve proposed by Mr. Waterston, the equation of which is $x=(y^2+1)^{-\frac{3}{2}}$. This curve being described by a graphic process once for all, gives approximately the distance of a planet from the earth by means of a straight line, the position of which is determined in each particular case. Mr. Challis determines the coefficients of this straight line by supposing that in the development of the heliocentric co-ordinates as a function of the time, we stop at the terms of the second degree (*Mem. Ast. Soc.* vol. xvii.). I have, however, succeeded in taking into account the terms multiplied by the cubes. One of the terms determined by Mr. Challis has for its coefficient $\frac{\theta\theta'}{2}$, and this factor in my investigation is replaced by $\frac{\theta'^2}{6}-\frac{\theta^3 c+\theta'^3 d}{6(\theta c+\theta'' d)}$. The symbols c, d, are the same as those in the *Theoria Motus*, p. 147. By the aid of this expression I have calculated small tables to be substituted for the graphic curve. The unknown quantity given by these tables is connected by a very simple relation with each of the unknown quantities of the problem, that is to say, with the radius vector, the curtate distance, and the arc whose value is given by an equation of the fourth degree in the method of Gauss. To give an idea of the practical utility of these tables, I may state that, upon applying them to a

Digitized by Google

numerical example, I obtained for the curtate distance the value 1·20181; employing the factor $\frac{6''}{2}$, I obtained 1·24994. Now the exact value is 1·20151. I have given the details of this case in the preface to the tables which I have sent to the *Astronomische Nachrichten.*'"

Simple Method of Finding the Focal Length of small Convex Lenses. By the Rev. T. W. Webb.

The determination of the focal length of a small convex lens is a matter of considerable difficulty, at least in the hands of an amateur. Not only is the process of direct measurement a delicate and somewhat troublesome one, but the result is not satisfactory, as it is complicated with uncertainties arising from the amount of spherical aberration, which with a large angle of aperture may have a considerable effect; from the thickness of the lens; and from the difference of the measure from the centre and from the margin of the posterior surface.

These difficulties, it is true, are avoided, as to the usual object of such measurements, by the employment of the dynameter, or any equivalent contrivance by which the focal image is measured instead of the focal length; but, as these optical means are not always at hand, it may perhaps be of some use to explain a mode of measurement practised by myself very successfully more than twenty years ago. The requisite apparatus, if it can be so termed, will be described in its original simplicity; a little ingenuity would easily improve it; but even in its first rude trial it was found adequate to its object.

Three pieces of cork are perforated by a knitting-needle, so as to slide along it. To the centre one is attached, in a vertical position, and with its axis parallel to the knitting-needle, the lens to be measured; in each of the others is inserted a piece of a sewing-needle, with the point uppermost, and having its length so regulated that a line joining these points would pass, as nearly as may be, through the centre of the lens. The cork discs carrying these needles are then moved backwards and forwards, till the inverted image of the one needle's point, formed by rays passing through the lens, is seen coincident and equally distinct with the other needle's point, when both are viewed at once through a tolerably strong magnifier applied to the eye, and directed towards the lens. Then, if the needle-points are sensibly equidistant on each side of the lens, a condition which can be quite sufficiently attained in the course of a few trials, it is evident that they occupy the conjugate foci, and the distance between them being carefully measured with compasses will be, as a very simple proposition in optics will show, *four times the amount of the focal length of the lens for parallel rays.*

Digitized by Google

The apparent defect of this method is the uncertainty whether the points, when the image of one is formed close to the other, are equidistant from the lens, the setting of which, or its form unless equally convex on each side, may render actual measurement unsatisfactory. A brief and simple calculation, however, founded upon Cor. 3 to Prop. xlv. of Wood's *Optics*, will show that any uncertainty in the focal length for parallel rays arising from this source of error would be so small in proportion to the corresponding change in the relative position of the conjugate foci, that the needle-points would be obviously and unmistakeably out of their proper places, that is, at very sensibly unequal distances from the lens, before the resulting focal length would be materially affected.

On the other hand, the advantages of this method are easily to be recognised. All errors are eliminated which arise from spherical aberration, the thickness of the lens, or the difference between the length of the marginal and that of the central ray; and the quantity actually measured, being four times greater than the final result, introduces into the latter a microscopical precision; while the actual process of measurement requires nothing but a careful eye, a steady hand, and a little experience, to ensure a degree of accuracy quite sufficient for all practical purposes.

Hardwick Parsonage, Herefordshire,
June 11, 1857.

Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the Year 1855, *under the Superintendence of Manuel J. Johnson, M.A., Radcliffe Observer.* Vol. XVI., Oxford, 1856.

The first part of this volume consists as usual of the meridian observations, with the necessary elements for reduction. Then follows a catalogue of stars observed in the year 1855, showing the result of each individual observation. This is succeeded by a catalogue of final results, exhibiting the places of 1149 stars reduced to the beginning of the year 1860, and a catalogue of 164 stars within 6° of the North Pole. The latter contains the mean places of all the stars in the vicinity of the pole reduced to the beginning of 1855, which have been observed at the Radcliffe Observatory during the period comprised between 1840 and 1855, both years inclusive.

The second part of the volume is devoted to the observations with the heliometer and the investigation of the results deducible from them. The parallaxes of a few of the more interesting stars form the object of research. The stars selected are:—*Castor;* the star *b*, employed by Mr. Johnson in his investigation of the parallax of 1830 Groombridge, given in the fourteenth volume of the Radcliffe Observations; *Arcturus;* and, lastly, *α Lyræ.*

Digitized by Google

The following are the assumed mean distances between the primary stars and the stars of comparisons :—

Castor	from 2517 B.A.C.			...	...	137″·6214
b	from *a*	...	...	...	...	101·8972
b	from *c*	...	...	...	...	12·7722
Arcturus	from 4731 B.A.C.			...	...	43·2572
α Lyræ	from 6319 B.A.C.			...	...	39·5807
α Lyræ	from *	...	...	...	...	30·8356

The results for *Castor* seem to indicate a measurable parallax amounting to 0″·198.

The parallax of *b* is found by comparison with *a* to be 0″·037 with a probable error of 0″·119. Assuming, then, as may safely be done, that the stars *a* and *b* have equal parallaxes, Mr. Johnson remarks that the most probable value of the parallax of 1830 *Groombridge* will be obtained by combining together the contemporary measured distances of *a* and *b* from that star. In this way he obtains 0″·033 for the parallax of 1830 *Groombridge* with a probable error of 0″·028 ; a result almost identical with that at which Otto Struve had previously arrived.

By a comparison with *c* Mr. Johnson obtained for the parallax of *b* the value −0″·298 with a probable error of 0″·156. However he points out several circumstances tending to show that this apparently anomalous result is entitled to very small weight.

For the parallax of *Arcturus*, Mr. Johnson obtains the value 0″·1377 with a probable error of 0″·052.

The value found by Professor Peters is 0″·127 ±0·073. (*Etudes d'Astronomie Stellaire*, p. 99.)

The small probable error in this case, compared with that obtained for *Castor*, seems to Mr. Johnson to indicate that long distances are not favourable to exact measurement.

The parallax of α *Lyræ* by comparison with 6349 B.A.C. is found to be +0″·2703, with the probable error ·0444 ; by comparison with the un-catalogued star, the result obtained is −0·1127, with the probable error 0″·0697. Combining together the two series of measures in one investigation, Mr. Johnson obtains a parallax amounting to 0″·1412, with a probable error of 0″·0467. Otto Struve gives a parallax equal to 0″·1549 ±·0120, as the combined result of his father's, his own, and Professor Peters' determinations. (*Monthly Notices*, vol. xiii. p. 74.)

The remaining part of the work is devoted to the meteorological operations at the Observatory.

Digitized by Google

CONTENTS.

	Page
Fellows elected	255
Note on the Eclipses of Agathocles, Larissa, and Thales, the Astronomer Royal	ib.
Observations in the Saturnian System, Capt. Jacob	ib.
New Double Stars, with remarks, Mr. A. Clark, Mr. Dawes	257
Observations of Minor Planets at the Royal Observatory	259
On the Application of the Formulæ for Precession, &c., Mr. Carrington ...	260
Results of Measures of *γ Virginis*, Admiral Smyth	262
Observations of Comet III., 1857, Dr. Donati	263
Elements of Comet III., 1857, M. Pape	ib.
New Planet (45), M. Goldschmidt	ib.
Elements of do., Dr. Forster	264
New Planet (46), Mr. Pogson	ib.
Elements of do., M. Pape	ib.
New Planet (47), M. Luther	ib.
New Comet (Comet IV., 1857), M. Dien, Prof. Habicht, Dr. Peters ...	265
" Elements, Dr. Bruhns	ib.
Note on the Star recently discovered in the Trapezium of the Nebula of *Orion*, M. Abbadie	266
On the Variability of 30 *Herculis*, Mr. Baxendell	ib.
Discovery of two New Planets, M. Goldschmidt	267
Observations of Comet IV., 1857, Dr. Trettenero	268
On a Method of finding the Distance of a Planet from the Earth, M. De Gasparis	ib.
Simple Method of Finding the Focal Length of small Convex Lenses, Rev. T. W. Webb	269
Notice of Vol. XVI. of the Radcliffe Observations	270

Digitized by Google

INDEX.

Page

Amphitrite, observations of 22, 52, 135
Antares, note on the observations of 11
Argelander, Professor, notice of his projected atlas of the northern hemisphere 121
———, ———, remarks on variable stars 148
Ariadne, discovery of 169
———, elements of 246
———, observations of 168, 198, 202, 224
Astronomer Royal, explanation of a contrivance for the support of the mercury vessel of the reflex zenith tube 159
———, suggestion respecting the variable star B.A.C. 3345,.. 169
———, on the means which will be available for correcting the measure of the Sun's distance in the next twenty-five years 208
———, researches on some ancient eclipses 233, 243
———, extracts from his Report to the Board of Visitors of the Royal Observatory 247
———, supplementary note on the eclipses of Agathocles, Larissa, and Thales 255

Babinet, M., on a method of finding the latitude 158
Baxendell, J., remarks on the variable star *R. Leonis* 235
———, —, on the variability of 30 *Herculis* 266
Beechey, Admiral, biographical notice of 93
Bompas, G. C., on the horary variation of meteors 147
Bond, Mr., on stellar photography 230
Brodie, F., on the manufacture of tubes for refracting telescopes 33
———, —, occultation of *Jupiter*, observed by 82
Bruhns, Dr., discovery of Comet II. 1857 161
———, ——, elements of ..... ib.
———, ——, elements of Comet IV. 1857 265
———, ——, elements of Comet V. 1857 266
Burr, T. W., occultations observed by 2, 53, 82, 203

Cambridge Observatory, notice of the labours of Professor Challis at the, during the past year 106
———, report of the Syndicate appointed to visit the 241
Challis, Professor, on the occultations of *Jupiter* and his satellites as observed at the Cambridge Observatory 137
Carrington, R. C., account of a recent tour of inspection into the present state of some of the German Observatories 43
———, solar spots observed by 53
———, description of a contrivance for measuring the area of object-glasses 83
———, note on the correction for precession 260
Clark, Alvan, measures of double stars 257
Comet I., 1857, observations of 170
——— —, ——, its passage over a fixed star 171
——— —, ——, discovered by Van Arsdale ..... ib.
——— —, ——, discovery of 160
——— —, ——, elements of 161, 173

Digitized by Google

Page

Comet II., 1857, discovery of 161
——— —, ——, elements of ..... ib.
——— —, ——, observations of 171, 172
——— III., 1857, discovery of 253
——— —, ——, observations of 263
——— —, ——, elements of ..... ib.
——— IV., 1857, discovery of 265
——— —, ——, observations of 268
——— —, ——, elements of 265
——— V., 1857, discovery of ..... ib.
——— —, ——, elements of 266
Criswick, Mr., remarks on an occultation of *Jupiter* by the Moon 72

D'Arrest, Professor, discovery of a comet by 160
Dawes, Rev. W. R., lunar occultation of *Jupiter's* fourth satellite, observed by 4
———, ————, telescopic appearances of *Saturn*, in 1855–6, observed by 7
———, ————, occultation of *Jupiter* observed by 76
———, ————, note on a lunar occultation of 27 *Arietis* 141
———, ————, remarks on Mr. Alvan Clark's measures of double stars 257
De Gasparis, Professor, on a numerical solution of Kepler's problem 155
— ————, ————, on a method of finding the distance of a planet from the Sun 268
De la Rue, Warren, occultation of *Jupiter*, observed by 1
———— —, ———, observations of *Jupiter*, by 5
————, ———, presents engravings of the planets *Jupiter* and *Saturn*, to the Society 221
Dell, T., occultation of *Jupiter*, observed by 81
Dien, M., discovery of Comet IV. 1857, by 265
Donati, Dr., observations of Comet III. 1857 263
Donkin, Thomas, biographical notice of 95
Double stars, micrometrical measures of γ *Virginis* 262
——— ——, observation of μ_2 *Herculis* 68
Dudley Observatory, notice of the establishment of 113
Dunkin, R., remarks on an occultation of *Jupiter* by the Moon 72

Eclipses, note on some ancient 55
Eclipses solar, account of the Astronomer Royal's researches on the eclipse of Agathocles, &c. 233, 243, 255
Edinburgh Observatory, notice of the labours at the, during the past year 107
Ellis, Mr., remarks on an occultation of *Jupiter* by the Moon 72
Euphrosyne, observations of 198
Eunomia, observations of 16, 22, 51

Fellows deceased 93
Fellows elected :—
J. P. Radcliffe, Esq. 1
Frederick John Evans, Esq., R.N. 21
Joseph Baxendell, Esq. 51
J. Masters Share, Esq. ..... ib.
Captain John Vine Hall ..... ib.
William Bolger Gibbs, Esq. ..... ib.
Lieut. Joseph Dayman, R.N. ..... ib.
George Andrew Rogers, Esq. ..... ib.
Captain A. S. H. Lowe ..... ib.
William Curtis Otter, Esq. 87
W. W. S. Stanhope, Esq. ..... ib.
James Simms, Esq. 135
W. J. Gillet, Esq. ..... ib.
Captain R. Fitzroy, R.N. ..... ib.
C. L. Prince, Esq. 223
Rev. T. W. Weare ..... ib.
Charles Howell, Esq. ..... ib.

Digitized by Google

Page

Fellows elected :—
Arthur Cayley, Esq. 255
Rev. W. H. Drew ..... ib.
J. J. Sylvester, Esq. ..... ib.
Fides, observations of 136, 167, 199
Fortuna, observations of 16, 21

Giles, William, biographical notice of 95
Goddard, J. F., occultation of *Jupiter*, observed by 4
Goldschmidt, discovery of new planets by 223, 263, 267
Graham, Robert Arthur, biographical notice of 95
Graves, Capt., biographical notice of 96
Grove, W. R., occultations of *Jupiter*, observed by 3, 78

Habicht, Professor, discovery of Comet IV. 1857 265
Hansen, Professor, on ancient eclipses 55
———, ———, Council report respecting the Lunar Tables of 120
———, ———, supplement to the Solar Tables of MM. Hansen and Olufsen 150
Hartnup, John, note on the division of the outer ring of *Saturn*, by 10
———, ———, occultation of *Jupiter*, observed by 73
———, ———, observations of Comet II., 1857 .....
Hebe, observations of 135, 168, 197
Higman, John Phillips, biographical notice of 98
Hind, J. R., note on the variable star *R. Leonis* 199
Hippisley, J., note on the observations of *Antares* 11
———, —, occultation of *Jupiter*, observed by 82
———, —, account of an experiment illustrative of the projection of stars on the Moon's disk 142
Hodgson, R., occultation of *Jupiter*, observed by 81
Hopkins, W., notice of his paper on the external temperature of the earth and the other planets of the solar system 190
Huggins, W., occultations, observed by 2, 82, 203
———, —, note accompanying drawings of *Jupiter*, *Mars*, &c. 23
Hygeia, observations of 16

Iris, observations of 168, 197, 224

Jacob, Capt., W. S., note accompanying drawings of *Mars* 10
———, ———, ———, on the projection of stars on the disk of the Moon .. 17
———, ———, ———, observations of *α Centauri* 19
———, ———, ———, occultation of *Jupiter* by the Moon, October 12th, 1856, observed by 52
———, ———, ———, occultation of the *Pleiades* by the Moon, observed by 53
———, ———, ———, notes on the satellites of *Saturn* 173
———, ———, ———, observations in the Saturnian system 255
Jeans, J. W., occultation of *Jupiter*, observed by 82
Johnson, M. J., occultation of *Jupiter*, observed by 74
———, ———, address on presenting the gold medal to M. Schwabe 126
———, ———, account of his labours at the Radcliffe Observatory 106
———, ———, note respecting the variable star *R. Leonis* 199
Jupiter, occultation of, by the Moon, November 8th, 1856 ..... 1, 2, 3, 4, 5
———, observations of, during October, 1856 ..... 5, 52
———, occultation of, Jan. 2, 1857, 68, 71, 73, 74, 75, 76, 78, 79, 81, 136, 141

Lassell, William, miscellaneous observations by 65
———, ———, observations of the satellites of *Uranus* 175
Lee, Dr., occultation of *Jupiter*, observed by 81
Le Verrier, notice of his *Annales de l' Observatoire de Paris* 117
Liverpool Observatory, notice of Mr. Hartnup's labours at the, during the past year 112
Lowndes, Rev. C., occultation of *Jupiter*, observed by 81

Digitized by Google

Page
Lynn, Mr., remarks on an occultation of *Jupiter* by the Moon 72
Lutetia, observations of..... 22, 136, 224

Madras Observatory, notice of the labours at the, during the past year 112
Main, Rev. R., remarks on an occultation of *Jupiter*, by the Moon 72
——, ——, on the value of the constant of refraction 183
Mann, Dr., occultation of *Jupiter*, observed by 75
Mars, note by Capt. Jacob, accompanying drawings of 10
Marth, Albert, notice of his researches on satellites 121
Massilia, observations of 16, 22, 52
May, R. C., drawing of *Jupiter's* disk 140
Melpomene, observations of..... 17, 21, 51
Miller, John Fletcher, biographical notice of 99
Memoirs, notice of the twenty-fifth volume of the 91
Monthly Notices, Council report on the 93
Morton, Frederick, observations of *Saturn's* rings..... 194

Nasmyth, James, observes an occultation of *Jupiter* 141
Neptune, satellite of, observations by Mr. Lassell 70

Occultation of the Pleiades, by the Moon 53
Orion, trapezium in the nebula of 68
——, observations of stars in the nebula of 225
——, discovery of a new star in the nebula of 245

Pape, M., elements of *Ariadne*..... 246
——, —— planet (44) 253
——, —— Comet III., 1857 263
——, —— planet (46) 264
Parthenope, observations of 136, 167
Peters, Dr. C. H. F., discovery of Comet IV. 1857 265
Peto, John, occultation of *Jupiter*, observed by 81
Plana, J., notice of his researches in the lunar theory 115
Planets, minor, magnitudes of thirty-six of the 12
——, ——, observations of..... 12, 16, 135, 167, 197, 224, 259
——, ——, discovered during the past year 114
——, (43) *Ariadne*, discovery of..... 169
——, ——, elements of..... 246
——, (44), discovery of 223
——, ——, elements of 253
——, (45), discovery of..... 263
——, ——, observation of..... 264
——, ——, elements of..... ib.
——, (46), discovery of ..... ib.
——, ——, elements of ..... ib.
——, (47), discovery of..... ib.
——, (48), discovery of..... 267
——, (49), discovery of..... ib.
Pogson, Norman, magnitudes of thirty-six of the minor planets for the first day of each month of the year 12
——, ——, on variable stars 23
——, ——, occultation of *Jupiter*, observed by..... 74
——, ——, on the variable star *U Geminorum* 200
——, ——, discovery of new planets by..... 169, 264
——, ——, observations of *Ariadne* 202
Polyhymnia, observations of..... 198
Porro, M., discovery of a new star in the nebula of *Orion*, by..... 245
Powell, Rev. Baden, on optical phenomena in occultations..... 143, 176
Precession, on the application of the formulæ for precession in the case of stars near the pole..... 260
Proserpine, observations of..... 168, 198
Psyche, observations of 168, 198

Digitized by Google

Page
Radcliffe Observatory, notice of Mr. Johnson's labours at the, during the past year 106
Redhill Observatory, notice of Mr. Carrington's labours at the, during the past year 112
Rothman, R. W., biographical notice of 103
Ross, Sir John, biographical notice of 100
Royal Observatory, notice of operations at the, during the past year 103

Saturn, observations of the close satellites of 67
———, note on the division of the outer ring of 10
Schwerd, Professor, notice of the reduction of his catalogue by M. Oeltzen 113.
Schwabe, M., account of the circumstances which induced him to observe the solar spots 241
Secchi, Professor, physical observations of *Mars* 207
Shadwell, Capt., notice of his "Formulæ of Navigation and Nautical Astronomy" .....
Simms, W. H., on the latitude of the Liverpool Observatory 28
———, ———, occultation of *Jupiter*, observed by 80
———, ———, on the correction of sextant observations 27, 176
Sheepshanks, Miss, presents to the Society all of the astronomical and other scientific instruments, which belonged to her brother the late Rev. Richard Sheepshanks 223
Smyth, Professor Piazzi, on the angular disturbances of ships, as affecting astronomical observations at sea 36
———, ——— ———, notice of his labours connected with the expedition to Teneriffe 107
———, ——— ———, experiences with a free-revolver stand for a telescope at sea 184
———, ——— ———, on the zodiacal light 204
Smyth, Admiral, micrometrical measures of γ *Virginis* 262
Society, present state of the 89
———, list of instruments in the possession of the 90
———, receipts of the 87
———, expenditure of the 88
———, assets and private property of the 88
———, stock of volumes of Memoirs of the 88
———, papers read before the, during the past year 121
———, list of public instituions, and persons who have contributed to the library, &c., since last anniversary 124
———, list of officers and council of the 131
Solar spots, observations on the 53, 252
Stars, deep red star 65
——, triple double star 66
——, occultation of, by the Moon 53
——, observations of α *Centauri* 19
——, occultation of *Spica Virginis* 203
Struve, Otto, remark respecting the faint ring of *Saturn* 193
———, observations of stars in the nebula of *Orion* 225
Stroud, Dr., suggestion respecting two lunar eclipses 189

Thalia, observations of 16
Tennant, Lieut., computations for the annular solar eclipse of 1857, by 18
———, on the determination of the latitude of Karachi 56
———, an examination of the figure of the Indian meridian, as deduced from the northern Indian arcs 58
———, on the effect of local attraction in modifying the apparent form of the earth, &c. 236
Trettenero, Dr., observations of Comet IV. 1857 268

Uranus, satellites of, observations by Mr. Lassell 175

Variable stars, note on 23

Digitized by Google

Page

Variable stars, *R Leonis*, notes on 199
————, *U Geminorum* 200
————, remarks on *R Leonis* 235
————, note on 30 *Herculis* 266

Waterston, J. J., an account of an experiment on the Sun's actinic power .. 205
Watson, John, occultation of *Jupiter* observed by..... 79
Webb, Rev. T. W., occultation of *Jupiter*, observed by 81
————, suggestions respecting a new mode of measuring the focal length of small convex lenses 269
Wrottesley, Lord, note on an occultation of *Jupiter*..... 4

Zodiacal light, remarks on the..... 204

Errata in Vol. XVII. of the Monthly Notices.

Page 2, line 3, *for* $4^h\ 22^m\ 26^s{\cdot}9$, *read* $4^h\ 42^m\ 26^s{\cdot}9$.
— 5, line 13, *for* ' of the bright edge,' *read* ' at the bright edge.'
— 10, line 10, *for* ' observation,' *read* ' obscuration.'
— 29, in Mr. Tennant's paper throughout, *for* ' frustrum,' *read* ' frustum.'
— 36, line 11, *for* ' weight of tube,' *read* ' weight of tube per square foot.'
— 145, in Professor's Powell's paper:—

	Lowndes	*for*	$\frac{1}{12{\cdot}1}$	*read*	$\frac{1}{17{\cdot}3}$
	Dawes	—	$\frac{1}{12{\cdot}5}$	—	$\frac{1}{15{\cdot}0}$
	Grove	—	$\frac{1}{13{\cdot}4}$	—	$\frac{1}{15{\cdot}1}$
	Lord Wrottesley	—	$\frac{1}{14{\cdot}1}$	—	$\frac{1}{16{\cdot}6}$
	Webb	—	$\frac{1}{15{\cdot}2}$	—	$\frac{1}{17{\cdot}8}$
— 147,	Chalmers	—	$\frac{1}{14{\cdot}4}$	—	$\frac{1}{15{\cdot}3}$

— — also *for* $3^{ft}\ 16^{in}$, *read* $3^{ft}\ 6^{in}$.
— 246, *dele* occultation of α *Virginis*, inserted at page 203.

For Errata in previous volumes, see pages 19, 49, 85, 162, 195. *Dele* the fifth in the list given at page 85, which had been already inserted in its proper place.

Erratum in the current Volume of Memoirs.

The reader is requested to correct the following clerical error in Mr. Main's paper on Refraction, published in the current volume of the *Memoirs* (vol. xxvi.):—

P. 62, line 11, *for* $30^{in}{\cdot}00$, *read* $29^{in}{\cdot}60$.

London:—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, October 28, 1857.

Digitized by Google

LIST OF PRESENTS

RECEIVED DURING THE SESSION OF 1856–57,

AND OF

BOOKS PURCHASED WITH THE TURNOR FUND

DURING THE SAME PERIOD,

FORMING

APPENDIX VIII.

To the Catalogue of the Library of the Royal Astronomical Society.

Académie des Sciences de l'Institut Imp. de France, Comptes Rendus Hebdomadaires, tome xlii., Nos. 18 to 26, tomes xliii., xliv., Nos. 1 to 7, 4to. *Paris*, 1856–57	L'Académie des Sciences.
——————, Supplément aux Comptes Rendus, tome i. 4to. *Paris*, 1856	———
Allé, Moritz, Opposition der Calliope vom Jahre 1857, 8vo. *Wien*, 1857	The Author.
American Academy of Arts and Sciences, Memoirs, vol. v., 4to. *Cambridge, U. S.* 1855	The American Academy.
——— Philosophical Society, Proceedings, Nos. 53, 54, 8vo. *Philadelphia*, 1856	The American Philosophical Society.
Annales Hydrographiques, January to June, 1854, 8vo. *Paris*, 1854	Le Dépôt Général de la Marine.
Annuaire des Marées des Côtes de France pour l'an 1855, 12mo. *Paris*, 1855	———
Anonymous, De l'Homme et de la Reproduction des différens Individus, 8vo. *Paris*, 1761	H. W. Buxton, Esq.

Digitized by Google

The Author. Argelander, F., Anzeige von einer auf der König. Universitats Sternwarte zu Bonn unternommenen Durchmusterung des nördlichen Himmels als Grundlage neuer Himmels charten, 8vo. *Bonn*, 1856

Dr. Peters. Astronomische Nachrichten, Nos. 1035–1094, 4to. *Altona*, 1856

The Author. Babbage, Charles, An Analysis of the Statistics of the Clearing-House, during the year 1839, 8vo. *London*, 1856

—— Bache, A. D., The Tides of the Atlantic and Pacific Coasts of the United States, the Gulf Stream and the Earthquake waves of December 1854, 8vo. *Newhaven, U. S.* 1856

The Berlin Academy. Berlin, Abhandlungen der K. Akademie der Wissenschaften, 1854. Erster Supplement Band, folio. *Berlin*, 1856

—— ———————————————, 1855, 4to. *Berlin*, 1856

—— ——— Monatsbericht, July 1855 to December 1856, 8vo. *Berlin*, 1855–56

—— ——— Akademische Sternkarten von der K. Akademie der Wissenschaften, Zone v. Uhr. Blatt 6, folio. *Berlin*, 1856

Prof. Encke. ——— Astronomisches Jahrbuch für 1859, 8vo. *Berlin*, 1856

The Royal Observatory at Berlin. ——— Astronomische Beobachtungen auf der königlichen Sternwarte, folio. *Berlin*, 1857

The Author. Bienaymé, J. J., Sur la Probabilité des Erreurs d'après la Méthode des moindres Carrés, 4to. *Paris, n. y.*

—— Birt, W. R., The Sailor's Guide, or short and easy Rules for Vessels in Revolving Storms, 12mo. *London*, 1857

The Hon. E. I. Company. Bombay, Magnetical and Meteorological Observations at Bombay, in the years 1854 and 1855, 4to. *Bombay*, 1856

The Observatory at Bonn. Bonn, Atlas des nordlichen Gestirnten Himmels für den anfang des Jahres 1855, entworfen auf der königlichen Sternwarte zu Bonn, atlas. *Bonn*, 1857

Dr. Bremiker. Bremiker, C., Georg's Freiherrn von Vega, Logarithmisch Trigonometrisches Handbuch vierzigste auflage, 8vo. *Berlin*, 1856

Digitized by Google

British Association for the Advancement of Science, Report of the Twenty-fifth Meeting, 1855, 8vo. *London*, 1856 — The British Association.

——— Report from the Mersey Inquiry Committee to the Meeting at Cheltenham, 1856, 8vo. *London*, 1856 — George Rennie, Esq.

Bruhns, C. C., De Planetis Minoribus inter Martem et Jovem circa Solem versantibus, 8vo. *Berolini*, 1856 — The Author.

Brussels, Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique, tome xxx. 4to. *Bruxelles*, 1857 — The Royal Academy at Brussels.

——— Couronnés et Mémoires des Savants étrangers publiés, par ditto, tomes xxvi., xxvii., xxviii., 4to. *Bruxelles*, 1855–56 — ———

——— Bulletins de ditto, 8vo. *Bruxelles*, 1855–56 — ———

——— Annuaire de ditto, 1856–57, 12mo. *Bruxelles*, 1856–57 — ———

——— Annuaire de l'Observatoire Royal, tome xi., 4to. *Bruxelles*, 1857 — The Royal Observatory at Brussels.

——— Annuaire de ditto, 1856–57, 12mo. *Bruxelles*, 1855–56 — ———

Burr, T. W., A Lecture on the History of the Law of Gravitation, delivered before the Islington Literary and Scientific Society, Nov. 8, 1856, 8vo. *London*, 1856 — The Author.

Busch, Dr., Beobachtungen und Wahrnemungen welche bei der totalen Sonnenfinsterniss am 28 Juli, 1851, gemacht worden sind, 8vo. *Königsberg*, 1852 — ———

Cambridge Observatory, Reports of the Observatory Syndicate, 1836 to 1856, 4to. *Cambridge, v. y.* — Rev. Prof. Challis.

——— Philosophical Society, Transactions, vol. ix., part 4, 4to. *Cambridge*, 1856 — The Cambridge Phil. Society.

Cape of Good Hope, Arc of Meridian, Mean Zenith Distances, Collection of the Results of Observation of each star at Heerelogements Berg, and Deduction of Mean Zenith Distances, 1843 Jan. 0, 4to. — Her Majesty's Government.

Catalogue Chronologique des Cartes, Plans, Vues de Côtes, Mémoires, Instructions Nautiques, &c., qui composent l'Hydrographie Française, 8vo. *Paris*, 1856 — Le Dépôt Général de la Marine.

Digitized by Google

The Society at Cherbourg. Cherbourg, Mémoires de la Société Impériale des Sciences Naturelles, tome iii., 8vo. *Paris*, 1855

Le Dépôt Général de la Marine. Cloué, G. C., Renseignments Hydrographiques sur la Mer d'Azof, 8vo. *Paris*, 1856

The Author. Colla, A., Astronomica Fenomeni Celeste nel Novembre 1856, 8vo. *Parma*, 1856

Dr. P. Pigorini. ——— Necrologia (Announcement of the death of M. Colla), Extract from the Gazette of Parma, 8vo. *Parma*, 1857

E. J. Cooper, Esq. Cooper, E. J., Catalogue of Stars near the Ecliptic observed at Markree, during the years 1854, 55, 56, vol. iv. 8vo. *Dublin*, 1856

M. L'Abbé Moigno. Cosmos, vols. ix., x., vol. xi. liv. 1, 8vo. *Paris*, 1856

The Society at Danzig. Danzig, Neuste Schriften der Naturforschenden Gesellschaft Fünften Bandes Drittes heft, 4to. *Danzig*, 1855

The Author. D'Arrest, H., Resultate aus Beobachtungen der Nebelflecken und Sternhaufen. Erste Reihe, 8vo. *Leipzig*, 1856

Le Dépôt Général de la Marine. Denmark, Le Pilote Danois, traduit de la dernière Edition du Danske Lods du Dépôt Hydrographique de Copenhague, 8vo. *Paris*, 1855

H. W. Buxton, Esq. Deslandes, M., Recueil de differens Traitez de Physique et d'Histoires Naturelles, 8vo. *Paris*, 1736

The Berlin Academy. Dove, H. W., Darstellung der Wärme-Erscheinungen durch fünftägige Mittel von 1782, bis 1855, mit besonderer Berücksichtigung strenger winter (Abhandlungen der k. Akadémie der Wissenschaften zu Berlin 1854. Erster Supplement Band), folio. *Berlin*, 1856

The Royal Society of Edinburgh. Edinburgh Royal Society, Transactions, vol. xxi., part 3, 4to. *Edinburgh*, 1856

——— ——————— Proceedings, vol. iii., No. 46, 8vo. *Edinburgh*, 1856

The Franklin Institute. Franklin Institute, Report on the twenty-fifth Exhibition of American Art Manufactures, held in the city of Philadelphia from the 11th to the 29th November, 1856, 8vo. *Philadelphia*, 1857

Digitized by Google

Franklin Institute, Journal of the, Nos. 366–378, 8vo. *Philadelphia*, 1856 — The Franklin Institute.

Galileo, Le Opere di Galileo Galilei, vols. xiii., xiv., xv., and Supplement, 8vo. *Firenze*, 1855–56 — Il Museo Fisica di Firenze.

Gautier, A., Notice sur les derniers Travaux d'Observation relatifs aux Anneaux de Saturne, 8vo. *Genève*, 1856 — The Author.

——— Review of "Memorie del Osservatorio del Collegio Romano." *Genève*, 1857 — ———

Geological Society, Transactions, vol. vii. part 4, 4to. *London*, 1856 — The Geological Society.

——— Quarterly Journal, Nos. 47 to 50, 8vo. *London*, 1856 — ———

George Town College, Catalogue of the Officers and Students for 1854–55, 8vo. *George Town*, 1855 — George Town College.

Göttingen, Nachrichten von der Georg-Augusts Universität und der Königl. Gesellschaft der Wissenschaften, vom Jahre 1856, 12mo. *Göttingen*, 1856 — The University of Göttingen.

Greenwich, Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, June 6, 1857, 4to. *London*, 1857 — The Astronomer Royal.

Grunert, J. A., Neue Näherungsweise auflösung der Keplerschen aufgabe, 8vo. *Wien*, 1856 — The Author.

——— Dissertatio de Area Trianguli Loxodromici in Superficie Ellipsoidis, 4to. *Gryphiswaldiæ*, 1856 — ———

Guarini, G., Palmieri, L., et Scacchi, A., Memoria sullo Incendio Vesuviano del mese di Maggio, 1855, 4to. *Napoli*, 1855 — The Royal Society at Naples.

Hardy, R. W. H., Incidental Remarks on some Properties of Light, being Part V. of an Essay on Vision, 8vo. *London*, 1856 — The Author.

Hansen, P. A., Auseinandersetzung einer zweckmässigen Methode zur Berechnung der absoluten Störungen der kleinen Planeten, 8vo. *Leipsig*, 1856 — ———

Hartnup, John, Results deduced from Observations taken with the Self-Registering Anemometer and Rain-Gauge at the Liverpool Observatory during the four Years ending December 31, 1855. *Liverpool*, 1856 — ———

Digitized by Google

The Author. Hartnup, John, On the Importance of testing Chronometers before they are used at Sea, with Examples to show how their most common Faults may be detected, 8vo. *Liverpool*, 1857

——— ——————— On the Method of testing Marine Meteorological Instruments recently introduced at the Liverpool Observatory, 8vo. *Liverpool*, 1856

——— ——————— Report on the Liverpool Observatory, addressed by the Astronomer to the Observatory Committee of the Town Council, June 1857, 8vo. *Liverpool*, 1857

The Harvard Observatory. Harvard College, Annals of the Astronomical Observatory, vol. i. part 1, 4to. *Cambridge, U.S.*, 1856

The Author. Heis, Professor, Bidliche darstellung der zu Munster vom 1 Dec. 1855, bis 30 Nov. 1856 . . . angestellten meteorologischen Beobachtungen. Sheet.

——— Hennessy, Henry, On the Influence of the Earth's Internal Structure on the Length of the Day, 8vo. *London*, 1856

——— Herschel, J. F. W., Essays from the Edinburgh and Quarterly Reviews, with Addresses and other Pieces, 8vo. *London*, 1857

Le Dépôt Général de la Marine. Hjorth, J., Description des Côtes de l'Esthonie, de la Livonie, de la Courlande (Russie), de la Prusse, et de la Poméranie jusqu'au Cap Darserort, 8vo. *Paris*, 1855

——— ——————— Description du Golfe de Finlande, et de l'entrée du Golfe de Bothnie, 8vo. *Paris*, 1854

George Town College. Humboldt, Alexander von, Cosmos, a Sketch of a Physical Description of the Universe, vols. i., ii., 8vo. *New York*, 1850

The Institute. Institut Impérial de France, Géographie Physique, Expériences sur la Direction des Courants de l'Océan Atlantique Septentrional (Lettre de S. A. S. le Prince Napoleon à M. Elie de Beaumont) Extrait des Comptes Rendus, 4°. *Paris*, 1856

——— ——————————— Mémoires, tome xxvii., 1re partie, 4to. *Paris*, 1856

——— ——————————— Mémoires par divers Savants, tome xiv., 4to. *Paris*, 1856

Digitized by Google

Jones, H. H., The Philosophy of Education, 8vo. *Manchester*, 1857	The Author.
Journals. The Assurance Magazine, Nos. 25 to 28, 8vo. *London*, 1856	The Institute of Actuaries.
——— The Astronomical Journal, Nos. 95 to 103, 4to. *Cambridge, U.S.*, 1856	Dr. B. A. Gould.
——— The Athenæum Journal, Nos. 1499 to 1549, 4to. *London*, 1856	The Editor.
——— The Civil Engineers and Architects' Journal, Nos. 271 to 280, 4to. *London*, 1856	———
——— The Critic, Nos. 366 to 390, folio. *London*, 1856	———
——— Herapath's Railway Journal, Nos. 892 to 943, 4to. *London*, 1856	J. Herapath, Esq.
——— L'Institut, No. 1196, folio. *Paris*, 1856	M. A. Colla.
——— The Literary Gazette, Nos. 2059–2111, 4to. *London*, 1856	The Editor.
——— The London, Dublin, and Edinburgh Philosophical Magazine, New Series, Nos. 75–90, 8vo. *London*, 1856	R. Taylor, Esq.
——— The Journal of the Photographic Society, Nos. 43–55, 8vo. *London*, 1856	The Photographic Society.
Keller, F. A. E., Exposé du Régime des Courants observés depuis le xvi^e^ siècle jusqu'à nos jours dans la Manche et la Mer d'Allemagne, et de leur supputation dans la Navigation générale à l'aide du Routier Compteur, 8vo. *Paris*, 1855	Le Dépôt Général de la Marine.
Königsberg, Astronomische Beobachtungen auf der königlichen Universitats-Sternwarte, vols. xxvi., xxvii., xxviii., xxx., folio. *Königsberg*, 1854	The Royal Observatory at Königsberg.
Le Gras, Alexandre, Pilote de la Mer Baltique de l'Amiral Suédois G. Klint, 8vo. *Paris*, 1856	Le Dépô Général de la Marine.
——————— Manuel de la Navigation dans la Mer Adriatique, 8vo. *Paris*, 1855	———
——————— Routier de l'Australie, traduit de l'Anglais, 8vo. *Paris*, 1855	———
Leibnitz, M. de, Recueil de diverses Pièces sur la Philosophie, les Mathématiques, l'Histoire, &c., ... publiées par Chrétien Kortholt, 8vo. *Hambourg*, 1734	H. W. Buxton, Esq.

Digitized by Google

The Linnean Society. Linnean Society, Transactions, vol. xxii. part 1, 4to. *London*, 1856

——— ——————— Proceedings, vol. i. No. 3, to vol. ii. No. 5, 8vo. *London*, 1856–57

The Author. Littrow, M., Ueber die neuesten Fortschritte der Astronomie Durchmesser und Massen der Asteroiden, 8vo. *Wien*,

——— ——————— Beilage Uebersicht des Sonnen-systems, 8vo. *Wien*

——— Littrow, Karl von, Drei Quellen über den Kometen von 1556, 8vo. *Wien*, 1856

——— ——————— Uber lichte fäden im Dunkeln Felde bei Meridian-Instrumenten, 8vo. *Wien*, 1856

The Liverpool Society. Liverpool Literary and Philosophical Society, Proceedings, No. 10, 8vo. *Liverpool*, 1856

The Hon. E. I. Company. Madras, Astronomical Observations made at the Hon. East India Company's Observatory, 1843–47, by T. G. Taylor, Esq., 1848–52, by Capt. W. K. Worster and W. S. Jacob, Esq., 4to. *Madras*, 1848–54

The Royal Academy of Sciences, Madrid. Madrid, Memorias de la Real Academia di Ciencias, tomo iii., iv., 4to. *Madrid*, 1856

——— ——— Resumen de las Actas de la Academia Real de Ciencias, 1850–51, 4to. *Madrid*, 1851

The Manchester Society. Manchester Literary and Philosophical Society, Memoirs, vol. xiii., 8vo. *London*, 1856

The Author. Mann, R. J., A Guide to Astronomical Science, 12mo. *London*, 1856

Le Dépôt Général de la Marine. Mouchez, E., Observations chronométriques faites pendant la Campagne de Circumnavigation de la Corvette la Capricieuse, 8vo. *Paris*, 1855

——— Moulac, V. A., Portulan des Côtes de la Manche, du Canal de Bristol et de la côte Sud d'Irlande, traduit de l'Anglais, 8vo. *Paris*, 1855

The Royal Observatory at Munich. Munich, Magnetische Ortsbestimmungen an verschiedenen Puncten der Königreichs Bayern und an einigen auswärtigen Stationen von Dr. J. Lamont, II. Theil, 8vo. *München*, 1856

Digitized by Google

Naples, Rendiconto della Societa Reale Borbonica, 1855, July to December, 4to. *Napoli*, 1855	The Royal Society at Naples.
Nautical Almanac and Astronomical Ephemeris for 1860, 8vo. *London*, 1856	The Lords Commissioners of the Admiralty.
Nautical Almanac, Ephemerides of the Minor Planets and *Neptune*, Supplement for 1860, 8vo. *London*, 1856	The Superintendent of the Nautical Almanac.
Observatories, Deutschlands vorzüglichste Sternwarten aus C. L. V. Littrow's Kalendar, 1848, 8vo. *Berlin*, 1848	R. C. Carrington, Esq.
Oudemans, J. A. C., Zweijæhrige Beobachtungen der Meisten jetzt bekannten veræn derlichen Sterne, 4to. *Amsterdam*, 1856	The Author.
——— Mémoire sur l'Orbite de la Comète périodique découverte par M. D'Arrest le 27 Juin, 1851, 4to. *Amsterdam*, 1854	———
Palermo Royal Observatory, Effemeridi Astronomiche, 1855–56, 8vo. *Palermo*, 1854–55	The Royal Observatory at Palermo.
———, Giornale Astronomico e Meteorologico, vol. i., 4to. *Palermo*, 1855	———
Paris Universal Exhibition, Reports, pts. 2, 3, 8vo. *London*, 1856	Her Majesty's Government.
Philological Society, Proceedings. Vols. i. to vi., Transactions, 1854, 1855, 8vo. *London*, *v.y.*	The Philological Society.
Pick, A. J., Ubersicht der Meteorologischen Beobachtungen an der Wiener Sternwarte in den Jahren 1851, 1852, 1853, 1854, 1855, folio. *Wien*, 1857	The Imp. Observatory at Vienna.
Plana, Jean, Mémoire sur l'Équation séculaire du moyen Mouvement de la Lune, 4to. *Turin*, 1856	The Author.
Plarr, Gustave, Essai d'une Théorie de la Figure de la Terre, basée sur le Calcul de l'Attraction des Sphéroides Hétérogènes, 4to. *Strasbourg*, 1850	———
——— Mémoire sur le Calcul de la Chaleur Solaire reçue en un point quelconque de la Surface de la Terre, dans l'hypothèse d'une Absorption de la Chaleur par l'Atmosphère, 4to. *Paris*, 1856	———

Digitized by Google

Sig. Secchi. Pontifica Corrispondenza meteorologica telegrafica in Roma. Primo semestro Luglio Decembre 1855, 4to. *Roma*, 1856

Rowland Hill, Esq. Postmaster-General, Third Report, 8vo. *London*, 1857

The Author. Quetelet, A., Rapport sur un Mémoire de Concours en Réponse à la première question du programme de 1856, 8vo. *Bruxelles*, 1856

——— ——— De l'Auteur M. Mahmoud Effendi, Astronome Egyptien, 8vo. *Bruxelles*, 1856

——— ——— Occultation de *Jupiter* par la Lune le 2nde Janvier 1857, 8vo. *Bruxelles*, 1857

——— ——— Des Observatoires du Nord de l'Allemagne et de la Hollande, et du Magnétisme terrestre dans ces deux Contrées, 8vo. *Bruxelles*, 1856

——— ——— Sur le Climat de la Belgique, de l'État du Ciel en général, 4to. *Bruxelles*, 1857

——— ——— Observations des Phénomènes périodiques, 4to. *Bruxelles*, 1857

——— ——— Rapports sur l'État et les Travaux de l'Observatoire Royal pendant les années 1855–56, 8vo. *Bruxelles*, 1857

——— ——— Tremblemens de Terre en 1855, par M. A. Perrey, rapport de M. A. Quetelet, 8vo. *Bruxelles*, 1857

The Radcliffe Trustees. Radcliffe Observatory, Astronomical and Meteorological Observations for the year 1855, vol. xvi., 8vo. *Oxford*, 1857

The Author. Ragona, Domenico, Osservazioni sulla seconda Cometa del 1854, 8vo. *Palermo*, 1854

——— ——— Relazione sull' ecclisse totale del Sole del 28

——— Luglio 1851, osservata in Rixthöft, 8vo. *Berlino*

The Registrar-General. Registrar-General of Births, Deaths, and Marriages, Weekly Return of Births and Deaths in London, vol. xvii., Nos. 28 52; vol. xviii., Nos. 1–26, 8vo. *London*, 1856

——— ——— Quarterly Return of Marriages, Births, and Deaths, in England, Nos. 30–31, 8vo. *London*, 1856

——— ——— Seventeenth Annual Report, 8vo. *London*, 1856

Digitized by Google

Robinson, Dr., The Article "Speculum," from Nichols' "Physical Sciences," 8vo. *Glasgow*, 1857	Rev. Dr. Robinson.
Rome, Memorie del nuovo Osservatorio del Collegio Romano, anno 1852–55, 8vo. *Roma*, 1856	The Collegio Romano.
Royal Dublin Society, Journal, Nos. 2–5, 8vo. *Dublin*, 1856	The Royal Dublin Society.
Royal Geographical Society, Proceedings, No. 4, 8vo. *London*, 1856	The Royal Geographical Society.
Royal Institution of Great Britain, Notices of the Meetings of the Members, part vi., 8vo. *London*, 1856	The Royal Institution.
——— List of Members, Officers, &c., for 1855, 8vo. *London*, 1856	———
Royal Irish Academy, Transactions, vol. xxiii., part 1, 4to. *Dublin*, 1856	The Royal Irish Academy.
——— Proceedings, vol. vi. part 3, 8vo. *Dublin*, 1856	———
Royal Society of London, Philosophical Transactions, vol. cxlvi. part 1, 4to. *London*, 1856	The Royal Society.
——— Proceedings, Nos. 22–25, 8vo. *London*	———
——— Address of the Rt. Hon. the Lord Wrottesley, &c., the President, delivered at the Anniversary Meeting of the Royal Society, on Monday Dec. 1, 1856, 8vo. *London*, 1856	———
——— Philosophical Transactions, vols. 1, 2, 7, 8, 11, 31, 32, 4to. *London*, *v.y.*	Mr. J. Williams.
Rümker, C., Handbuch der Schiffarts kunde, 8vo. *Hamburg*, 1857	The Author.
——— Neue Folge der Mittleren oerter von Fixsternen für den aufang von 1850, folio. *Hamburg*, 1856	———
——— Meteorological Observations made at the Observatory Hamburg, 4to. *Hamburg*, 1856	———
Secchi, A., Intorno ad un Nuovo Barometografo, 4to. *Roma*, 1857	———
——— Un Orologio Solare Antico, illustrato dal P. Angelo Secchi, 8vo. *Roma*, 1857	———

Digitized by Google

The Observatory of George Town College. — Sestini, B., Observations of Solar Spots made at the Observatory of George Town College, Sept. 20 to Nov. 6, 1850, 4to. *Washington*, 1853

——— ——— A Treatise of Analytical Geometry, proposed by, 8vo. *Washington*, 1852

——— ——— A Treatise on Algebra, 8vo. *Baltimore*, 1855

——— ——— Elementary Algebra, 8vo. *Baltimore*, 1855

The Author. — Share, J. M., The Lee Shore, or Loss of H. M. S. Warrior, and other Poems, 12mo. *London*, 1856

——— ——— Tables for ascertaining a Ship's Distance from the Summit of High Land, having taken its Altitude above the Sea Horizon with a Sextant, together with a Short Distance Table, 4to. *London*, 1856

The Smithsonian Institution. — Smithsonian Institution, Smithsonian Contributions to Knowledge, vol. viii., 4to. *Washington*, 1856

The Society of Arts. — Society of Arts, Journal, Nos. ccxvi. to ccxlii., 8vo. *London*, 1857

Mr. J. Williams. — Souciet, P. F., Observations Mathématiques, Astronomiques, &c. tirées des Anciens Livres Chinois ou faites nouvellement aux Indes et à la Chine par les Pères de la Compagnie de Jésus, 4to. *Paris*, 1729

The Author. — Statter, Dover, The Decimal System as a whole, in its relation to Time, Measure, Weight, Capacity, and Money, 8vo. *London*, 1856

The Imperial Academy of Sciences. — St. Pétersburg, Mémoires présentés à l'Académie Impériale des Sciences, par divers Savants, tome vii., 4to. *St. Pétersbourg*, 1854

——— ——— Compte Rendu de l'Académie Imp. de St. Pétersbourg, 1852–53–54–55, 8vo. *St. Pétersbourg*, 1853–56

W. Gravatt, Esq. — Tables, Specimens of Tables calculated, Stereomoulded and printed by Machinery, 8vo. *London*, 1857

Her Majesty's Government. — Toronto, Observations made at the Magnetical and Meteorological Observatory, vol. iii. 1846–47–48, 4to. *London*, 1857

Digitized by Google

Treadwell, D., The Practicability of constructing Cannon of great Calibre, capable of enduring long-continued Use under full Charges, 8vo. *Cambridge*, 1856 — The Author.

United States, Army Meteorological Register for Twelve Years, from 1843 to 1854 inclusive, compiled from Observations made by the Officers of the Medical Department of the Army at the Military Posts of the United States, prepared under the Direction of Brevet Brigadier-General T. Lawson, 4to. *Washington*, 1855 — The American Government.

Upsala, Nova Acta Regiæ Societatis Scientiarum Upsaliensis Seriæ Tertiæ, vols. i., ii., Fas. 1, 4to. *Upsaliæ*, 1855 — The Royal Society at Upsala.

Vienna, Annalen der k. k. Sternwarte in Wien, Dritter folge sechster Band Jahrgang 1856, 8vo. *Wien*, 1857 — The Imperial Observatory at Vienna.

——— Denkschriften der Kaiserlichen Akademie der Wissenschaften, Zehnter und Eilfter Bande, 4to. *Wien*, 1855-56 — The Imperial Academy of Sciences at Vienna.

——— Sitzungberichte der do. B. 18, 19, 20, pt. i., 8vo. *Wien*, 1856 — ———

——— Almanach der do., 1856, 8vo. *Wien*, 1856 — ———

——— Jahrbucher der k. k. Central-anstalt fur Meteorologie und Erdmagnetismus von Karl Kreil, IV. Band Jahrgang 1852, 4to. *Wien*, 1856 — ———

Villarceau, Ivon, Sur le prochain Rétour de la Comète découverte par M. D'Arrest en 1851, 4to. *Paris*, 1857 — The Author.

Whewell, W., Supplementary Volume to the Second Edition of the "History of the Inductive Sciences," containing the new matter of the Third Edition, 8vo. *London*, 1857 — ———

Wildig, G. B., A Geometrical System of Conic Sections for the Use of Mathematical Students at the Royal Liverpool Institution (with the Author's MS. Corrections and Additions), 8vo. *Cambridge*, 1822 — Rev. J. Ebden.

Winnecke, F. A. T., De Stella ♀ Coronæ Borealis Duplici, 8vo. *Berolini*, 1856 — The Author.

Wolf, Rudolf, Mittheilungen über die Sonnenflecken, 8vo. *Zurich*, 1856 — ———

Digitized by Google

The Author. Woodhouse, W. S. B., Weights and Measures of all Nations, and an Analysis of the Christian, Hebrew, and Mahometan Calendars, 12mo. *London*, 1856

The Zoological Society. Zoological Society, Proceedings, Nos. 299 to 313, 8vo. *London*, 1857

The Author. Zuckermann, B., Jahresbericht des jüdisch-theologischen Seminars "Fraenkelscher Stiftung." Ueber Sabbatjahrcyclus und Jobelperiode, 4to. *Breslau*, 1857

The Society at Zurich. Zurich, Mittheilungen der Naturforschenden Gessellschaft, Heft 3, 10, 8vo. *Zurich*, 1849–56

——— ——— Vierteljahrs-schrift der Naturforschenden Gesellschaft in Zurich redigirt von Dr. Rudolf Wolf, Erster Jahrgang, Parts 1 to 4, 8vo. *Zurich*, 1856

Miscellaneous Articles.

Sir Wm. Keith Murray. Five Photographic Views of Ochterlyne (N.B.) Observatory and Instruments.

Le Dépôt Général de la Marine. Forty-seven Charts.

L'Observatoire Impérial de Paris. Six Ecliptic Charts.

The American Government. Ten Charts of Harbours, &c. in the United States of America.

Purchased with the Turnor Fund.

Paris, Annales de l'Observatoire Impérial de Paris, tomes 1, 2, par U. J. Le Verrier, 4to. *Paris*, 1856

Digitized by Google

Heath, Robert, Astronomia Accurata, or the Royal Astronomer and Navigator, containing New Improvements in Astronomy, Chronology, and Navigation, particularly new and correct Solar and Lunar Tables, with Precepts and Examples for their Use, according to Old or New Style, 4to.
London, 1760

Royal Society, Philosophical Transactions at Large, 1733 to 1749, 4to. *London*, *v. y.*

Digitized by Google

31677

Digitized by Google

Digitized by Google

Digitized by Google